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# STUDIES ON A POPULATION CYCLE OF SNOWSHOE HARES ON THE LAKE ALEXANDER AREA

## III. EFFECT OF REPRODUCTION AND MORTALITY OF YOUNG HARES ON THE CYCLE[1]

*R. G. Green*[2] *and C. A. Evans*[3]

In two previous papers (Green and Evans, 1940a and 1940b) we have described the trapping and banding methods used on the Lake Alexander Area in studying the population of snowshoe hares, and have presented the results of our investigations in terms of annual censuses, determinations of age ratios, and analyses of the yearly mortality among different age groups of hares at various times during the cycle.

The present paper concerns primarily the reproduction of snowshoe hares on the Lake Alexander Area. This phase of the investigation was based principally on the study of female animals collected by shooting or trapping, as samples of the normal hare population on the area. In the early years of the investigation, when the animals were abundant, a sample of 30 hares was taken each month from April through September or October. In subsequent years, the number was reduced to 20 each month; and, finally, from 1936 through 1938, when hares became increasingly scarce, even fewer were taken, both because of the difficulty encountered in collecting them and because we did not wish further to reduce the population.

In assembling the data for this paper, we were careful to eliminate, so far as possible, all immature female hares from our calculations. However, some of the hares born in the first litter of each season, about May 1, are so large after a period of six or eight weeks, that it is difficult to distinguish them, by gross examination, from adults. The figures for the incidence of pregnancy during the latter part of June and all of July, therefore, are probably somewhat lower than they should be, and, accordingly, our estimate of the reproduction of hares on the Lake Alexander Area is doubtless a conservative one.

All female hares taken on the area were subjected to a thorough post-mortem examination including a search for embryos. Recognizable embryos were first noted the latter part of March or the first few days in April of each year and were seen in a variable proportion of the females collected from that time well into July. No significant difference could be detected in the duration of the breeding seasons in the several years. As no pregnant females were found before

[1] From the Cooperative Wildlife Disease Investigation of the University of Minnesota, the Minnesota Department of Conservation, and the Bureau of Biological Survey, U. S. Department of the Interior.

[2] Department of Bacteriology and Immunology, University of Minnesota.

[3] Bureau of Biological Survey, U. S. Department of the Interior.

March 25 and only one was taken after July 31, these dates were set as the limits of the breeding season in analyzing our data. We examined 230 female hares in the seven years, 1932–38. The number found to be pregnant in each of the years is shown in Table 1.

TABLE 1

AVERAGE NUMBER OF EMBRYOS TO THE PREGNANT HARE, 1932–38

| *Year* | *Number of pregnant hares collected* | *Total number of embryos* | *Average number of embryos to the pregnancy* |
|---|---|---|---|
| 1932 | 23 | 73 | 3.17 |
| 1933 | 12 | 43 | 3.58 |
| 1934 | 34 | 95 | 2.79 |
| 1935 | 35 | 89 | 2.54 |
| 1936 | 20 | 61 | 3.05 |
| 1937 | 11 | 29 | 2.64 |
| 1938 | 5 | 16 | 3.20 |
| 1932–38 | 140 | 406 | 2.90 |

One of the explanations postulated for the periodic fluctuation in the populations of cyclic species is that the size of the litters or the number of eggs to a clutch is small during the years when the animals decrease in numbers and large when they are increasing (MacFarlane, 1905). Our data show rather clearly that this is not the case with snowshoe rabbits. From one to five embryos were found in each of the 140 pregnant hares examined, except in one instance in which there were seven. The average number of embryos to a pregnant hare, as shown in Table 1, was 2.90 and the average number in each of the several years did not vary significantly from this figure. By the method of analysis of variance, we have found that the variation in the numbers of embryos to the pregnant hare between the years was not significantly greater than that within the years. Similarly, although the data for the years 1932 and 1935 showed the maximum difference in the average number of embryos to the pregnancy, statistical analysis shows that this difference was not significant. In other words, litters of snowshoe hares were of the same size in 1932, when the population was approaching a maximum, as they were in 1936, when it was rapidly nearing its lowest level.

Having determined the average number of embryos to the litter, we next attempted to ascertain the average number of litters produced annually by a female hare. To do this precisely, it would be necessary to know at all times during the reproductive season what proportion of the female hares on the area were pregnant, information that could be obtained only by collecting an extremely large number of hares. Inasmuch as it was impossible to get a sample sufficiently large during one season without materially affecting the population, we collected a smaller number of hares each year and have combined the data for the seven years in an attempt to obtain a satisfactory approximation of the incidence of pregnancy at various times during the reproductive season. This grouping of the data from the several years, we believe, yields valid results, since there was no apparent difference in the duration of the reproductive period nor in the incidence of pregnancy in the various years. The data are presented in Table 2. Each female hare examined between March 25 and July 31 is represented by a figure that indicates the number of recognizable embryos she carried. In the columns to the right the numbers of pregnant and nonpregnant hares have been totaled for each day of

the month during the seven-year period of investigation. In order to determine the changing proportion of pregnant animals throughout the season, we have divided the Table into successive groups of about 20 hares (in some groups, from 19 to 23 animals were included to avoid separating hares trapped on the same day of the month).

Figure 1 presents graphically the results obtained by grouping the data in this manner.

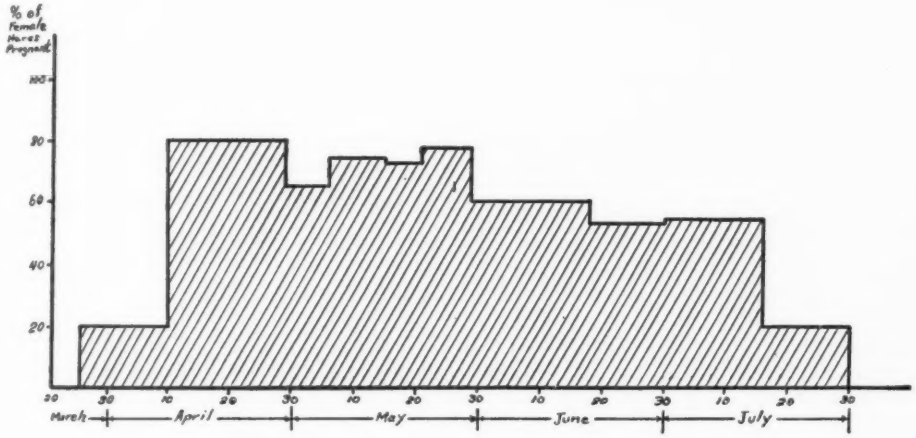


Fig. 1. Incidence of pregnancy among female snowshoe hares on the Lake Alexander Area.

Inspection of this figure shows that 20 per cent of the female hares examined between March 25 and April 10 of the seven years were pregnant. The proportion rose rapidly to an average of 81 per cent during the two and one-half weeks following April 10, after which there was a definite, although apparently not drastic, reduction. A second rise occurred early in May and the incidence of pregnancy was maintained at the high level of 70 or 80 per cent until the last of that month. Throughout June and the first half of July, between 50 and 60 per cent of the female hares collected were pregnant, and among those collected during the last two weeks of July only 20 per cent contained embryos. According to our data, the number of pregnant hares in August was negligible. However, it is probable that many of the females examined were immature, inasmuch as hares of the season's first litter have grown to the size of adults by the first of August. Studies of captive hares on the Lake Alexander Area indicate that between 10 and 20 per cent of the adult female hares on the area give birth to young during August. Most of the hares that have young in August are included in the "20 per cent pregnant during the latter half of July" and accordingly enter into our calculations. In view of these facts, it appears that our estimate of the number of young born is about five per cent less than the actual number.

Figure 1 indicates the *average* incidence of pregnancy during the periods

indicated, but it does not show brief fluctuations that occur in any given year. It is apparent from inspection of Table 2 that the incidence of pregnancy at the beginning of the reproductive season rises sharply, probably to a level of about 90 per cent. At the end of April there is a brief reduction in pregnancies, which must be much greater than is shown by Figure 1, for the hares that become pregnant late in March or early in April deliver their young the latter part of April or the first few days in May. It is further apparent, from the records of animals taken in May, that snowshoe hares become pregnant again a few days after the birth of their first litter of the season. The gradual de-

TABLE 2

ANALYSIS OF REPRODUCTIVE STATE OF FEMALE HARES COLLECTED DURING BREEDING SEASONS, 1932–38, INCLUSIVE

| Date | Number of embryos found in each female hare collected | | | | | | | Total number of hares | | Percentage of female hares pregnant (in groups of approximately 20) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | Pregnant | Nonpregnant | |
| March 25 | | | | | | | | | | |
| 26 | | | 0, 0* | | | | | | 2 | |
| 27 | | | 0, 2† | | | | | 1 | 1 | |
| 28 | | | | 3 | | | | 1 | | |
| 29 | | | | | | | | | | |
| 30 | | | | | | | | | | |
| 31 | | | | 0 | | | | | 1 | |
| April 1 | | | | | | | | | | 20 |
| 2 | | 0 | 0 | | 0 | | 2 | 1 | 3 | |
| 3 | 0 | 0, 0 | | | | | | | 3 | |
| 4 | | 0, 0 | | | | | | | 2 | |
| 5 | | | 0 | 2 | | | | 1 | 1 | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | 0 | | | | 1 | |
| 9 | | | | 0 | 0 | | | | 2 | |
| 10 | | | 0 | | | | | | 1 | |
| 11 | | | | | | | 3 | 1 | | |
| 12 | | 0 | | 2, 1 | | | | 2 | 1 | |
| 13 | 3, 3 | | 2 | | 0 | | | 3 | 1 | |
| 14 | | | | | 0 | | | | 1 | 81 |
| 15 | | | | | | | | | | |
| 16 | | | 2 | | 2 | 3 | | 3 | | |
| 17 | | | | 2 | | 3, 3 | | 3 | | |
| 18 | | | 2 | | | | | 1 | | |
| 19 | 1, 3, 2 | | | 2 | | | | 4 | | |
| 20 | | | | | | 2, 2, 3 | | 3 | | |
| 21 | 4, 3 | | | | | | | 2 | | |
| 22 | | | | 0, 2 | | 1, 0, 3 | | 3 | 2 | |
| 23 | 2 | | 2, 1 | | | | | 3 | | |
| 24 | 2 | | | 3 | | | | 2 | | 81 |
| 25 | 1 | | | | | | | 1 | | |
| 26 | 2 | | | | | | | 1 | | |
| 27 | | | | 1 | | | | 1 | | |
| 28 | 3, 0 | 0 | | | | | | 1 | 2 | |
| 29 | 0 | | | 2 | | 3 | | 2 | 1 | |
| 30 | 0, 0 | | 3, 3, 1 | 1 | | 2 | | 5 | 2 | |

* 0, 0 indicates that no embryos were found in two females.

† 0, 2 indicates that no embryos were found in one female but that two embryos were found in another hare collected on the same date.

TABLE 2 (Continued)

| Date | | Number of embryos found in each female hare collected | | | | | | | Total number of hares | | Percentage of female hares pregnant (in groups of approximately 20) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | Pregnant | Nonpregnant | |
| May | 1 | | | 2, 0 | 2 | | | | 2 | 1 | |
| | 2 | 0 | 0 | 2 | | | | | 1 | 2 | 65 |
| | 3 | | | 0 | 3 | | | 4 | 2 | 1 | |
| | 4 | | | | | | | | | | |
| | 5 | | | | | 2 | | | 1 | | |
| May | 6 | | 3 | | 0 | | | | 1 | 1 | |
| | 7 | | | 3 | | | | | 1 | | |
| | 8 | | | 0 | | | | | | 1 | |
| | 9 | | 2 | | 3 | | | | 2 | | |
| | 10 | | 4, 0, 5 | | 4, 3 | | | 5 | 5 | 1 | 74 |
| | 11 | | 3 | 3 | | | | | 2 | | |
| | 12 | | | | | 5 | 0 | | 1 | 1 | |
| | 13 | | 4 | | | 2 | | | 2 | | |
| | 14 | | | 4, 0 | 2, 3 | 0 | | | 3 | 2 | |
| | 15 | | 3 | 3, 3, 4 | | | | | 4 | | |
| | 16 | 0 | 3 | 0 | | 0 | | | 1 | 3 | |
| | 17 | 0, 0 | 0 | 3, 3 | 3 | | | | 3 | 3 | 73 |
| | 18 | 2 | | 4 | | | | | 2 | | |
| | 19 | 4, 7 | | | | | | | 2 | | |
| | 20 | 4, 5 | | | | 2, 3 | | | 4 | | |
| | 21 | 4 | | | | 0 | | | 1 | 1 | |
| | 22 | | | 2, 3 | 3 | | | | 3 | | |
| | 23 | | | | 3 | 2, 0 | | | 2 | 1 | |
| | 24 | 4 | | 4, 3 | 3 | | | | 4 | | 77 |
| | 25 | 3, 4 | | 4 | | | | | 3 | | |
| | 26 | | | | | | | | | | |
| | 27 | 5 | | | | | | | 1 | | |
| | 28 | 2 | | 0, 0, 0 | | 4, 2 | | | 3 | 3 | |
| | 29 | | | 0, 0, 0 | | 2, 5 | | | 2 | 3 | |
| | 30 | | | | | | | | | | |
| | 31 | | | 3 | | | | | 1 | | |
| June | 1 | | | | | | | | | | |
| | 2 | | | 3 | | | | | 1 | | |
| | 3 | | | | | | | | | | |
| | 4 | | | | 0, 3 | | | | 1 | 1 | |
| | 5 | | | 0 | | 3 | | | 1 | 1 | |
| | 6 | | | | | | | | | | |
| | 7 | | | | | | | | | | 60 |
| | 8 | | | | | | | | | | |
| | 9 | | | | | 5 | | | 1 | | |
| | 10 | | | | | | | | | | |
| | 11 | | | 0 | | | | | | 1 | |
| | 12 | | | | 3 | | | | 1 | | |
| | 13 | | | | 1 | | | | 1 | | |
| | 14 | | | 2 | | | | | 1 | | |
| | 15 | | | | | 0 | | | | 1 | |
| | 16 | | | | | 4, 3 | | | 2 | | |
| | 17 | | | | 0 | | | | | 1 | |
| June | 18 | | | 2 | | | | | 1 | | |
| | 19 | | | | 2 | 3 | | | 2 | | |
| | 20 | | | 2 | | | | | 1 | | |
| | 21 | | | | 3 | | | | 1 | | |
| | 22 | | | 0 | | 0 | | | | 2 | |
| | 23 | | | 2 | | | | | 1 | | |
| | 24 | | | | | 0 | | | | 1 | 53 |
| | 25 | | | | 0 | 0, 0 | | | | 3 | |
| | 26 | | | | 2 | 4, 5 | | | 3 | | |

TABLE 2 (Continued)

| Date | | Number of embryos found in each female hare collected | | | | | | | Total number of hares | | Percentage of female hares pregnant (in groups of approximately 20) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | Pregnant | Nonpregnant | |
| | 27 | | | 0 | | | | | | 1 | |
| | 28 | | | | | | | | | | |
| | 29 | | | | 0 | 0, 1‡ | | | | 2 | |
| | 30 | | | 3 | | | | | 1 | | |
| July | 1 | | | | 3, 4 | | 4, 0 | | 3 | 1 | |
| | 2 | | | | 3 | | | | 1 | | |
| | 3 | | 4 | 0 | | | | | 1 | 1 | |
| | 4 | | | | | | | | | | |
| | 5 | | 0 | 0 | | | | | | 2 | |
| | 6 | | 0 | | | | | | | 1 | |
| | 7 | | | | | | | | | | |
| | 8 | | | | 0 | | | | | 1 | 54 |
| | 9 | | | | | | | | | | |
| | 10 | | | | 2, 0 | | | | 1 | 1 | |
| | 11 | | 4, 5 | | | | | | 2 | | |
| | 12 | | | 5 | | | | | 1 | | |
| | 13 | | 3, 0 | | 4 | | | | 2 | 1 | |
| | 14 | | 0 | | | | | | | 1 | |
| | 15 | | 0 | | 4 | | | | 1 | 1 | |
| | 16 | | | | 0 | | | | | 1 | |
| | 17 | | | | | | | | | | |
| | 18 | | 0 | 0 | 0 | | | | | 3 | |
| | 19 | | | 0 | 2 | | | | 1 | 1 | |
| | 20 | | | | | | | | | | |
| | 21 | | | | | | | | | | |
| | 22 | | | | | 2 | | | 1 | | |
| | 23 | | | | | 0 | | | | 1 | 20 |
| | 24 | | | | | | | | | | |
| | 25 | | | | | | | | | | |
| | 26 | | | 0 | | | | | | 1 | |
| | 27 | | | | | 0, 0 | | | | 2 | |
| | 28 | 0, 0 | | | | | | | | 2 | |
| | 29 | | | | 0 | 0, 0 | | 2 | 1 | 3 | |
| | 30 | | | 5 | | | | | 1 | | |
| | 31 | | | 0 | | 0 | | | | 2 | |

‡ Ectopic.

crease in the proportion of females found to carry embryos in the months of June and July indicates that some, but not all, of the snowshoe hares have three litters a year. It is not unlikely that a small percentage have four litters.

In order to estimate the average number of litters born to the female hare each year, we first determined the number of days during one reproductive season that the females carry embryos large enough to be seen. This was accomplished by multiplying the proportion of hares pregnant in a given period by the number of days in the period (see Table 2 and Figure 1) and totaling the results. For example, from March 25 through April 9, a period of 16 days, 20 per cent of the female hares examined were pregnant; therefore, 16 was multiplied by 0.20. During the 19 days from April 10 through April 28, 81 per cent of the female hares examined contained embryos; accordingly, 19 was multiplied by 0.81. The data for the remainder of the season

were similary treated, as shown in Table 3.

Calculations indicated that the average number of days of recognizable pregnancy to the female hare for the entire season was 70. According to the average number of embryos to the pregnancy, the average number of litters to the female hare, and, as reported in a previous paper (Green and Evans, 1940a), the population of snowshoe hares to the square mile, we were able

TABLE 3

CALCULATION OF THE AVERAGE NUMBER OF DAYS OF RECOGNIZABLE PREGNANCY TO THE FEMALE HARE IN ONE REPRODUCTIVE SEASON*

| *Dates* | *Number of days* | *Proportion of female hares pregnant* | *Average number of days of recognizable pregnancy to the hare* |
|---|---|---|---|
| March 25–April 9 | 16 | 20 | 3.20 |
| April 10–April 19 | 10 | 81 | 8.10 |
| April 20–April 28 | 9 | 81 | 7.29 |
| April 29–May 5 | 7 | 65 | 4.55 |
| May 6–May 14 | 9 | 74 | 6.66 |
| May 15–May 20 | 6 | 73 | 4.38 |
| May 21–May 28 | 8 | 77 | 6.16 |
| May 29–June 17 | 20 | 60 | 12.00 |
| June 18–June 30 | 13 | 53 | 6.89 |
| July 1–July 15 | 15 | 54 | 8.10 |
| July 16–July 31 | 16 | 20 | 3.20 |
| Total number of days of pregnancy to the female | | | 70.53 |

* Data in this table are taken from Table 2.

Grange (Grange, 1932), the period of gestation of the snowshoe hare is 36 days. Since it is probable that the embryo is too small to be recognizable during the first five or six days after fertilization of the ovum, there remain about 30 days of recognizable pregnancy to each period of gestation. The data presented in Table 2 and Figure 1 also suggest that delivery occurs about 30 days after embryos become large enough to be seen. Accordingly, we have divided the average number of days of recognizable pregnancy (70) by 30 to obtain the average number of litters (2.3) produced by each female hare in one season.

## YOUNG PRODUCED TO THE SQUARE MILE

With acceptably accurate figures for to estimate the number of young produced each year. The calculations are shown in Table 4.

The figures for the population of snowshoe hares to the square mile used in Table 4 were obtained by the trapping and banding method (except in 1932) and, as explained in a preceding paper, apply to the middle of the "precensus" period; that is, about February 1 (see Paper I of this series, Green and Evans, 1940a). We have shown that a mortality of about 45 per cent of the entire population of hares occurred in a period of 10 weeks during the winter of each of two successive years, and that the total annual mortality among adult hares is about 70 per cent (Green and Evans, 1940a and 1940b). In order to approximate the number of hares to the square mile during the reproductive

TABLE 4

NUMBER OF YOUNG PRODUCED TO THE SQUARE MILE, 1932-39

| Average number of embryos to the pregnancy, 2.90 | | × | Yearly average number of litters to the female, 2.3 | | = | Average number of young produced to the female annually, 6.6 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Population to the square mile in February | ×2/3 = | Population to the square mile about April 1 | ÷2 = | Number of females to the square mile | × | Number of young produced to the female | = | Number of young to the square mile |
| 1932 | 275 | ×2/3 = | 183 | ÷2 = | 91 | × | 6.6 | = | 600 |
| 1933 | 478 | ×2/3 = | 319 | ÷2 = | 159 | × | 6.6 | = | 1,049 |
| 1934 | 374 | ×2/3 = | 249 | ÷2 = | 124 | × | 6.6 | = | 818 |
| 1935 | 356 | ×2/3 = | 237 | ÷2 = | 118 | × | 6.6 | = | 779 |
| 1936 | 246 | ×2/3 = | 164 | ÷2 = | 82 | × | 6.6 | = | 541 |
| 1937 | 151 | ×2/3 = | 101 | ÷2 = | 50 | × | 6.6 | = | 330 |
| 1938 | 32 | ×2/3 = | 21 | ÷2 = | 10 | × | 6.6 | = | 66 |
| 1939 | 73 | ×2/3 = | 49 | ÷2 = | 24 | × | 6.6 | = | 158 |

season, therefore, the figures for the population of hares in February have been reduced by one-third.

Inasmuch as females constitute about 50 per cent of a snowshoe hare population, the total number of hares to the square mile divided by two gives the number of females to the square mile. This figure was multiplied by the average number of young produced to the female. (The latter figure was obtained as shown in Table 4, by multiplying the average number of embryos to a pregnancy by the average number of litters to the female.) In this manner, estimates were made of the number of young hares produced to the square mile during each year from 1932 through 1939.

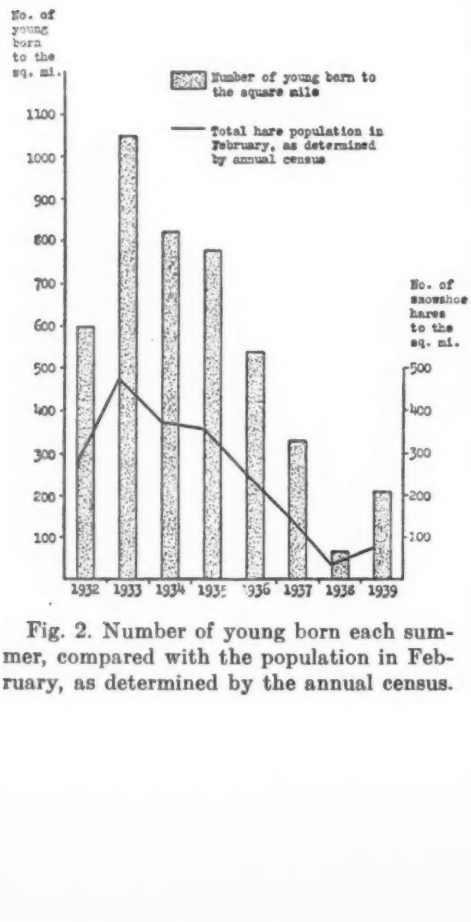


Fig. 2. Number of young born each summer, compared with the population in February, as determined by the annual census.

In Figure 2 are depicted the changes in population of snowshoe hares from 1932 through 1939, as determined by our census for February of each year, together with the number of young produced in each of those years, as estimated from the calculations in Table 4.

## MORTALITY AMONG HARES DURING THE FIRST NINE MONTHS OF LIFE, 1932–39

If our analysis of the reproduction of snowshoe hares on the Lake Alexander Area has had even a moderate degree of accuracy, it is apparent that by far the greatest mortality occurs during the

years when snowshoe hares are most abundant, just preceding the obvious "die-off." For example, in 1933, when snowshoe hares had reached maximum abundance, about 1,000 young were born on each square mile. However, as the annual census showed a reduction of about 100 to the square mile from February 1933 to February 1934, there must have been a mortality of about 1,100 hares to the square mile. During the following year, the population was maintained at a relatively constant level, as indicated by the February census. Nevertheless, approximately 800 snowshoe hares died on each square mile during that time. In contrast, when the population was reduced from a low level of 151 to the square mile in February 1937 to the lowest point of the entire cycle, 32 to the square mile in February 1938, the number of hares that died was about 400 to the square mile, or half the number that died in the period from 1934 to 1935.

In an earlier paper (Green and Evans, 1940b) we presented data which strongly indicate that the mortality among adult hares from one year to the next has been fairly constant throughout the period of our investigation on the Lake Alexander Area; that is, about 70 per cent of the hares present on the area in February of one year were dead by February of the next year. This fact, together with evidence indicating the maintenance of a constant reproductive rate throughout the years of our study suggests that the characteristic changes in population over a period of years are due to differences in the proportion of young hares that survive.

From data presented in the second paper of this series (Green and Evans 1940b), it was possible to calculate the number of yearling hares to the square mile in *February* of each year from 1934 through 1939. Comparison of these data with those pertaining to the number of young born to the square mile each year yields a measure of the mortality of hares during approximately the first nine months of life; that is, from the time of their birth to the following February. The data are assembled in Table 5.

TABLE 5

SURVIVAL OF HARES FROM TIME OF THEIR BIRTH TO THE FOLLOWING FEBRUARY

| *Year* | *Number of young produced to the square mile* | *Number of yearlings to the square mile in the following February* | *Percentage of survival* |
|---|---|---|---|
| 1932 | 600 | 287 to 430 | 48 to 72 |
| 1933 | 1,049 | 241 | 23 |
| 1934 | 818 | 236 | 29 |
| 1935 | 779 | 137 | 18 |
| 1936 | 541 | 67 | 12 |
| 1937 | 330 | 27 | 8 |
| 1938 | 66 | 60 | 91 |

Age ratios could not be calculated in the trapping season of 1932–33. However, the data for other years, when hares were numerous (1934 and 1935) or were increasing (1939), suggest by analogy that yearlings almost certainly constituted between 60 and 90 per cent of the total population in 1933. Calculations based on these two figures indicate that between 48 and 72 per cent of the hares born in the previous year survived to February 1933. Corresponding figures for the other years are based on the determination of age ratios from trapping records, as explained in detail in a previous paper (Green and Evans, 1940b).

In Figure 3, the mortality among young hares from the time of birth to

the following February is shown graphically for each year from 1932 through 1938 (see data in Table 5 also).

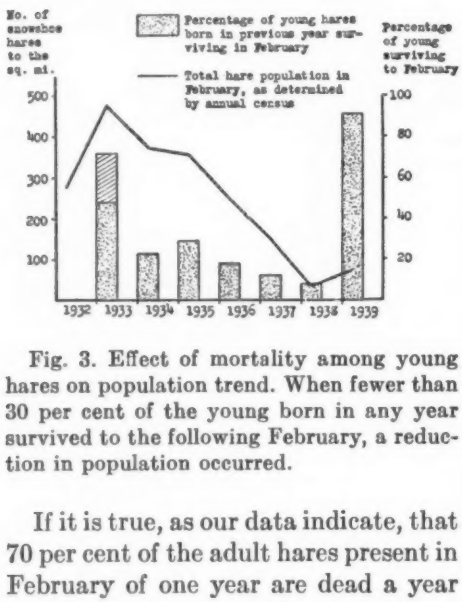


Fig. 3. Effect of mortality among young hares on population trend. When fewer than 30 per cent of the young born in any year survived to the following February, a reduction in population occurred.

If it is true, as our data indicate, that 70 per cent of the adult hares present in February of one year are dead a year later, that about one-third of the hares alive in February die before the beginning of the reproductive period, and that an average of 6.6 young are born to each female annually, then we can conclude that about 30 per cent of the young must survive until the following February, if they are to replace the adult hares that die and keep the population at a constant level. Figure 3 shows this relationship as it is brought out by our data for the Lake Alexander Area. When less than 30 per cent of the young survived to February, the population decreased; when more than 30 per cent survived, the population increased. Of the young hares born in 1932, between 48 and 72 per cent survived until the following February. The result was that the population was higher in February 1933 than a year earlier. Of the hares born during the summer of 1933, only 23 per cent survived to February 1934, and, as a result, there was a moderate decrease in population. According to our data, 29 per cent of the young born in the summer of 1934 were alive in February 1935, and, as would be expected, the population was then about the same as it had been one year earlier. During the succeeding three years, the mortality rate among young hares increased, as shown by the progressively smaller figures for the survival of young hares, 18, 12, and 8 per cent, respectively. Because of the increased mortality among immature hares, the population declined steadily and rather steeply during these years. The end of the so-called "die-off" came by crisis rather than by lysis. Of the young born in the summer of 1937 only eight per cent lived to February, the lowest rate of survival recorded in the seven years of our investigation. The following year, 91 per cent of the young survived to February, the highest rate of survival in the seven years. The factor that had killed more and more young each year from 1933 through 1937 had suddenly disappeared. As a result of decreased mortality among young hares, the population began to increase for the first time in four years. The census for February 1939 showed that the population on the Lake Alexander Area had doubled since the low point of the cycle was reached in 1938.

## SUMMARY

From the evidence presented in the three papers of this series we have arrived at the following concept of the changes in population of snowshoe

hares on the Lake Alexander Area during the cycle that has just been completed:

1. After a period of decimation that terminated about 1926, snowshoe hares gradually increased in numbers until 1933, when they reached a maximum population of 500 hares to the square mile. During the next two years there was a moderate decrease in numbers of hares in some parts of the area; then, beginning in 1935, there was a sharp, continuous decline throughout the area, which continued until a minimum of about 32 hares to the square mile was reached, as shown in our census for February 1938. The beginning of recovery from this decimation was marked in 1939 by an increase in numbers of hares on the area to approximately double the number in 1938.

2. The proportion of yearling hares in the population on the area varied somewhat in different stages of the cycle. In 1934, 1935, and 1936, when hares were decreasing moderately from maximum abundance, yearlings constituted about 60 per cent of the entire population. In 1937, only 44 per cent were yearlings. In the following two years, 1938 and 1939, the proportion of yearlings was greatly increased, mounting to 80 per cent or more of all the hares on the area.

3. The annual mortality among *adult* hares of the various age groups was remarkably close to 70 per cent each year from 1933 through 1937. From February 1937 to February 1938, a somewhat higher mortality occurred, as our data indicated that only three or four per cent of the hares present at the beginning of this period survived a year later. During the following year, the mortality among adult hares not only returned to normal but probably was a little less than usual, as, according to our calculations, 41 per cent survived.

From these data we concluded that the mortality among adult snowshoe hares was relatively constant throughout the years in which hares decreased from maximum abundance to scarcity, and then began once more to increase in numbers. Obviously, the mortality among adult hares was not the principal cause of the "die-off."

4. So far as could be determined, the duration of the reproductive season, the proportion of female hares pregnant at various times during that season, and the average number of embryos to the pregnant hare showed no significant differences in the various years; in other words, a relatively constant reproductive rate was maintained throughout the cycle.

5. The mortality among young hares (from the time of birth to February of the following year) showed pronounced variations synchronous with the several stages of the cycle. When fewer than 30 per cent of the estimated number of young born in a given summer survived to the following February, a decrease in population occurred. This was the case in the years 1933 through 1937, when the rate of survival varied between 8 and 29 per cent. Of the hares born in 1932 and in 1938, a much greater proportion survived, and, as a result, the population increased in those years.

## CONCLUSIONS

The principal factor in the fluctuations of the population of snowshoe hares on the Lake Alexander Area during the recent cycle was the changing

mortality among immature hares during the first nine months of life. A high mortality among the young hares caused the decline in population; a low mortality in young hares resulted in the increase in population before and after the period of decline. Neither the mortality among adult hares nor the rate of reproduction appear to have varied enough to be of major importance as a cause of the cycle.

The role that shock disease plays as a cause of some of the phenomena described in this series of papers on population studies has been discussed in a previous paper (Green, Larson, and Bell, 1939).

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R. G. Green
C. A. Evans
University of Minnesota
Minneapolis, Minnesota

# THE PHENOLOGY OF SOME BOB-WHITE FOOD AND COVER PLANTS IN BRAZOS COUNTY, TEXAS

*Tandy P. Chenault*[1]

The maintenance of a bob-white (*Colinus virginianus*)[2] population depends upon a continuing supply of food during all seasons. The present investigation[3] was planned to determine the periods of the year in which some of the most important food plants produce the seeds on which bob-whites largely feed, and also the times when these and other plants are available for shelter.

The study was made in pastures 8, 9, and 10 of the College Farm located about 2 miles southwest of the main campus of the Agricultural and Mechanical College of Texas, College Station, Brazos County, Texas. The area is typical of a considerable extent of pasture land in the post-oak type of central eastern Texas.

Brazos County lies on the western edge of the "East Texas Timber Belt." In their Soil Survey of Brazos County, Veatch and Waldrop (1916) have noted that there is little variation in the temperature or precipitation in different parts of the County. Warm weather frequently occurs in January, causing the trees to bud and flower, and subsequent low temperatures may damage both crops and trees. The weather is never sufficiently severe to injure winter grain or to winter kill fruit buds. The annual rainfall averages about 38 inches, the heaviest precipitation occurring in April and May. Droughts are frequent and the average annual temperature is about 68° Fahrenheit. Although a temperature of 110°F. has been recorded, periods of extremely hot weather are infrequent and of short duration. The winters are generally mild, although sudden changes in temperature, accompanied by cold winds blowing from the north, often occur. During these cold storms or "northers," which seldom last for more than three days, freezing temperatures are common. Northers sometimes occur as late as April. The average date for the last killing frost in spring is March 4, and for the first in fall, November 21. Tharp (1926) and Veatch and Waldrop (1916) place Brazos County in the oak-hickory association, the one universal dominant of which is the post oak (*Quercus stellata*).

Attention to any area of vegetation usually discloses a dominant species (Clements, 1920), the others being either subdominant or secondary. According to Weaver and Clements (1929), vegetation shows not only gen-

[1] Contribution from the Texas Cooperative Wildlife Research Unit, the Agricultural and Mechanical College of Texas, the Texas Game, Fish, and Oyster Commission, the American Wildlife Institute, and the Biological Survey, United States Department of the Interior, cooperating.

[2] The bob-white population of Brazos County is a mixture of *C. v. virginianus* and *C. v. texanus*.

[3] I wish to acknowledge the valued assistance of Professors Walter P. Taylor, R. G. Reeves, and William B. Davis, Agricultural and Mechanical College of Texas, which enabled me to carry this study to completion. Chester Higgs, Executive Assistant, Texas Agricultural Experiment Station, kindly permitted access to meteorological records.

eral dominance, but also local dominance at different seasons. For example, in grassland in early spring local areas produce societies of abundant and vigorously growing herbs that flower and mature seed. Such plant colonies, according to Weaver and Clements (*ibid.*), may make maximum demands upon the habitat before the grasses overtop them. By early summer, spring societies are inconspicuous and others become locally dominant. The appearance of vegetation again changes as summer gives way to fall. These adjustments of species to seasonal changes are known as aspects (Clements, 1920, p. 127; Carpenter, 1938, p. 27). Aspects are alternations of species in time.

Warner (1936), working in southeastern Texas exclusive of the longleaf-pine type, has compiled a list of bobwhite food plants according to the soils where they are found, their relative values, their periods of seeding and fruiting, and their uses to quail. He states that while the food of the bobwhite quail is largely seeds, wild fruits, green stuff, and many kinds of insects also are consumed.

The basic information for the relative evaluation of quail food plants has been obtained from Warner's paper (*l.c.*) and from the chapter on food and feeding habits by Handley in Stoddard's The Bobwhite Quail (1932, pp. 113–165). Handley's conclusions are based on analyses of more than two thousand stomachs and crops collected in the southeastern states during all months of the year.

## MATERIAL AND METHODS

Field observations were made by the writer each week from September 1, 1936, to April 1, 1938. Before the findings could be satisfactorily recorded, it was necessary to identify the principal plants, and to determine which were valuable as food and cover for quail. Some of these identifications could not be made until the plants' blooming periods, consequently, information on their earlier stages was not obtained. Data were procured for as many food and cover plants as possible during their periods of growth, blooming, maturing, and dissemination of seeds. As nearly as practicable, the first date of each phase of plant development was recorded; in some instances, however, the beginning of a particular phase was overlooked. Not only were the phases recorded at each field observation, but notes were kept on the abundance or scarcity of each species. The peaks of the various phases (growth, blooming, maturing, and dissemination of seeds) were determined by analyzing the data at the close of each month. It was thus easy to determine the particular period during which a species or a group of species was at the peak of a given activity-phase.

## SEASONAL WAVES OF FOOD AND COVER PLANTS IN RELATION TO THE BOB-WHITE

Plants furnish food to quail in the form of seeds or green stuff or both. Many serve exclusively as cover, others are of value for both food and cover. From the standpoint of food availability to quail, dissemination of the seeds proved to be the most important phase. Flowering played a minor role except in rare instances. Flowering, nevertheless, was important as an obvious indicator of the time when certain species came

into prominence. The plants fell naturally into four major groups, namely, those flowering in winter, spring, summer, and autumn. Each of these assemblages could be divided into "waves," composed of groups of plants flowering at about the same time. The blooming period of one group often merged into that of the next; such overlapping was common throughout the year.

*Winter Flowering Plants.* There was only one wave of winter flowering plants. This was composed of eleven species, namely,

*Arabis virginica*—Virginia rockcress
*Capsella bursa-pastoris*—shepherd's-purse
*Stellaria media*—common chickweed
*Cerastium viscosum*—mouse-ear chickweed
*Chaerophyllum dasycarpum*—chervil
*Poa annua*—annual bluegrass
*Panicum helleri*—panic grass
*Dichondra carolinensis*—dichondra
*Lonicera sempervirens*—honeysuckle
*Lithospermum angustifolium*—yellow puccoon
*Rubus trivialis*—dewberry

The peak of the growth period of winter flowering plants occurred during the month of January. Flowering was at its height in February, and maturing of seed in April. The seeds were likewise disseminated in April.

The period of growth of one of these species, chervil, was year-long, but its blooming, maturing, and dissemination of seeds were restricted to 3 months (see Chart 1). Another interesting plant from the standpoint of overlapping activities was common chickweed, which flowered, matured, and disseminated its seeds, continuously from January through April. All of its activities, however, came to an abrupt close May 1.

Valuable to bob-white as green food were the following: Virginia rockcress, common chickweed, mouse-ear chickweed, chervil, annual bluegrass, and dichondra. Green food plants were available from October to May. Panic grass was consumed both as green food and as seed. On several occasions bob-whites were observed plucking foliage from the young succulent plants, and later in the season picking the seeds from mature heads. Panic grass was available as green food from late winter to February 1. Seeds in the immature heads were available from April 1 to July 15. Since dissemination of the seeds occurred as soon as they matured, it was impracticable to make a distinction between the periods for these two phases of growth.

Honeysuckle and dewberry were the only winter flowering plants observed that were of value both for food and cover. Honeysuckle made effective cover where its long runners climbed over heaps of brush or similar objects. Its fruits were available April 1 to June 1. Dewberry was of major importance as cover as well as food. During its fruiting period (June), bob-whites often were flushed from its brushy tangle. Approximately 80 of these birds were counted between April and July in an area where dewberry occurred. Frequently from 35 to 50 bob-whites were seen feeding upon the berries, and in many cases it was impossible to see all of the birds known to be present in the dense undergrowth. The thorns on the dewberry runners made it difficult for predators to pursue the quail. Both plants afforded cover from March 1 to July 1.

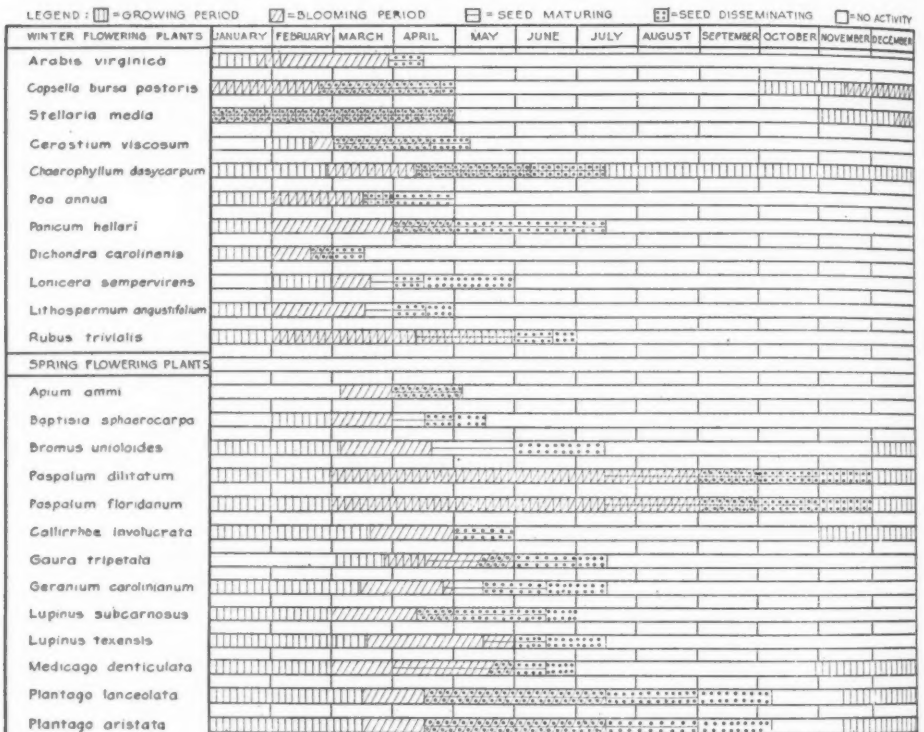
*Spring Flowering Plants.* Plants that bloomed in spring usually sprouted during January and February. This

group was the most numerous in species of all. It appeared in three waves, in March, April, and May. Many species of this group extended their activity into the summer and a few into the autumn.

The March wave was composed of:

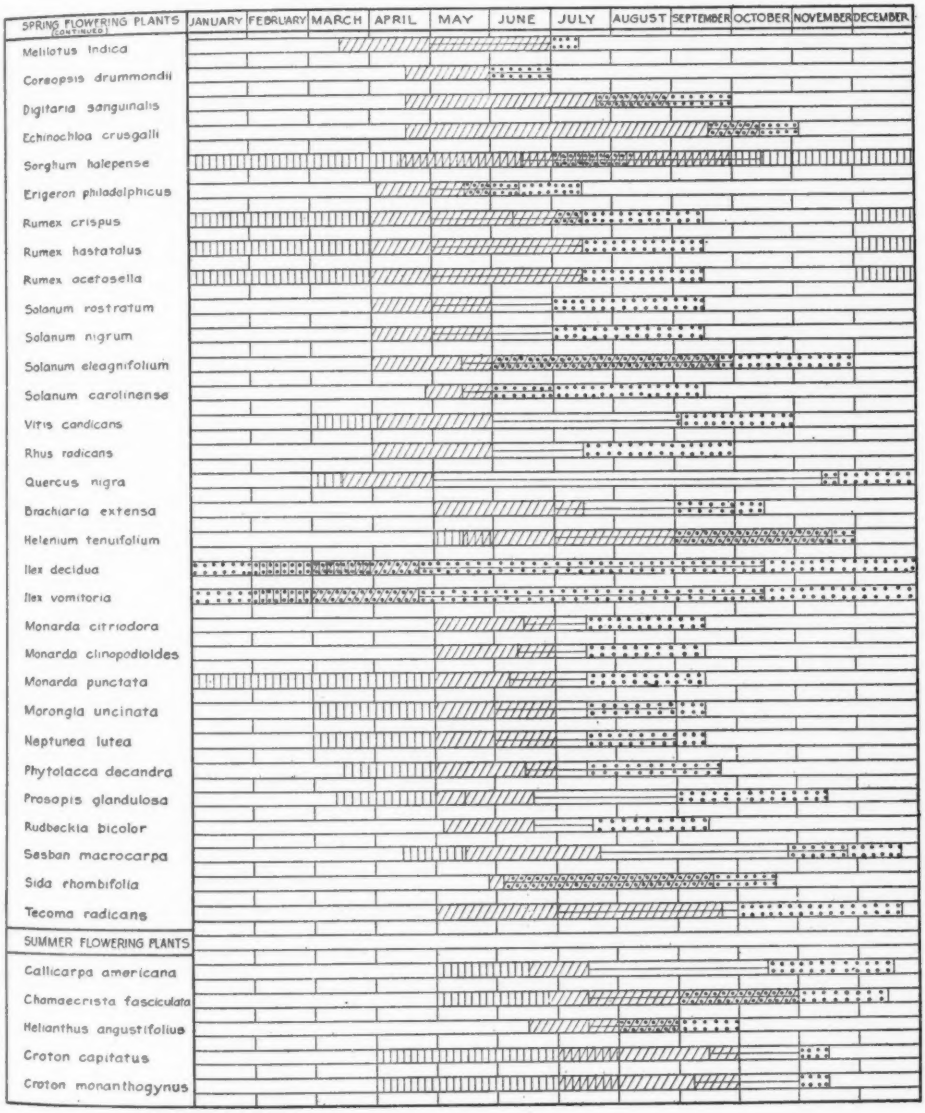
*Apium ammi*—Marsh-parsley
*Baptisia sphaerocarpa*—false-indigo
*Bromus unioloides*—rescue grass
*Paspalum dilatatum*—Dallis grass
*Paspalum floridanum*—paspalum
*Callirrhoe involucrata*—winecup

CHART I PHENOLOGICAL ACTIVITIES OF SOME QUAIL FOOD AND COVER PLANTS IN BRAZOS COUNTY, TEXAS



*Gaura tripetala*—gaura
*Geranium carolinianum*—cranesbill
*Lupinus subcarnosus and L. texensis*—bluebonnets
*Medicago denticulata*—burclover
*Melilotus indica*—yellow sweetclover
*Plantago lanceolata*—lanceleaf plantain
*Plantago aristata*—bracted plantain
*Oxalis stricta*—yellow woodsorrel
*Quercus stellata*—post oak
*Quercus nigra*—water oak
*Ilex vomitoria*—yaupon

CHART I (CONTINUED). PHENOLOGICAL ACTIVITIES OF SOME QUAIL FOOD AND COVER PLANTS IN BRAZOS COUNTY, TEXAS



*Ilex decidua*—possumhaw
*Senecio ampullaceus and S. lobatus*—ragworts
*Stellaria nuttallii*—Nuttall's chickweed
*Vicia caroliniana*—Carolina vetch
*Valerianella radiata*—lambslettuce
*Trifolium carolinianum*—Carolina clover

The April wave consisted of:

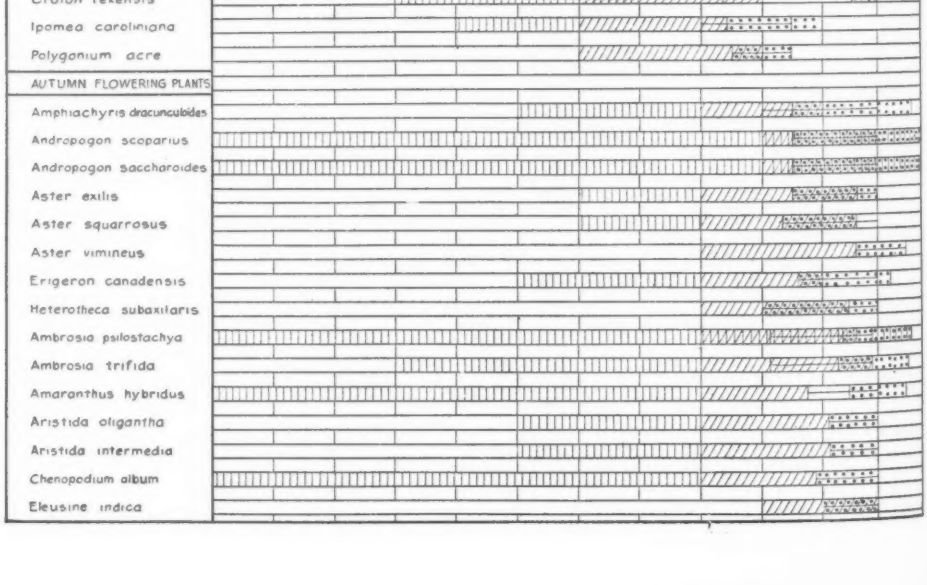
*Bifora americana*—bifora
*Daucus pusillus*—Queen Anne's lace
*Gaura parviflora and G. sinuata*—gauras
*Lepidium viginicum*—peppergrass
*Coreopsis drummondii*—Drummond's coreopsis
*Digitaria sanguinalis*—crabgrass
*Echinochloa crus-galli*—wild millet
*Sorghum halepense*—Johnson grass
*Erigeron philadelphicus*—fleabane
*Rumex crispus, R. hastatulus,* and *R. acetosella*—fieldsorrels
*Solanum nigrum*—black nightshade
*Solanum carolinense*—horsenettle
*Solanum eleagnifolium*—white horsenettle
*Solanum rostratum*—buffalo-bur
*Vitis candicans*—mustang grape
*Rhus radicans*—poison-ivy
*Brachiaria extensa*—brachiaria
*Helenium tenuifolium*—bitterweed

The May wave included:

*Monarda clinopodioides*—monarda
*Monarda punctata*—horsemint or spotted beebalm
*Monarda citriodora*—lemon-mint
*Morongia uncinata*—red sensitive-briar
*Neptuna lutea*—yellow sensitive-vine
*Phytolacca decandra*—pokeberry
*Prosopis glandulosa*—mesquite
*Sesbania macrocarpa*—sesban
*Rudbeckia bicolor*—pinewoods coneflower
*Sida rhombifolia*—sida
*Tecoma radicans*—trumpetvine

The following spring flowering plants were valuable to the bob-white chiefly as green food: marsh-parsley, lambslettuce, Queen Anne's lace, and peppergrass. On several occasions bob-whites were flushed from areas where these species were abundant, and close observation showed that the birds had been feeding upon their foliage which was

CHART 1 (CONTINUED) PHENOLOGICAL ACTIVITIES OF SOME QUAIL FOOD AND COVER PLANTS IN BRAZOS COUNTY, TEXAS



available as green food from February 1 until May 1.

Winecup, yellow woodsorrel, Nuttall's chickweed, Carolina clover, and crabgrass were valuable to the bobwhite chiefly for their seeds. Most of them were available as food from April 1 to June 15. Crabgrass, however, did not disseminate seeds until July 25. The length of time seeds were available after dissemination was not determined for any of the plants. Presumably many seeds falling to the ground were obtainable for a number of months.

Lanceleaf and bracted plantains were the only species of the spring group that were important to the bobwhite for both seeds and foliage. They furnished green food between November 15 and March 1, seeds between April 15 and October 10.

Pokeberry was of value largely as green food. The birds were observed feeding upon its foliage between March 15 and April 1 at which time it was in the early sprouting stage. Although the growing period of pokeberry continued until May 1, there was no evidence that bob-whites consumed its foliage after the first of April. The species was of little value for cover because the individual plants were widely scattered.

Rescue, Dallis, and Johnson grasses, wild millet, cranesbill, bluebonnets, burclover, yellow sweetclover, Carolina vetch, the fieldsorrels, brachiaria, lemon-mint and horsemint, monarda, and the sensitive-vines were the spring plants valuable for cover, green food, and seeds. The majority were obtainable as green food from January 1 to March 1. The fieldsorrels, cranesbill, bluebonnets, and burclover were available as green food early in December. Johnson and Dallis grasses provided green food the entire year.

While the seeds from most of these plants were disseminated between June 1 and August 1, those of many of them were shed from April 1 until as late as December 15. Johnson and Dallis grasses were the last to cease this activity.

By April 1, yellow sweetclover, Carolina vetch, burclover, bluebonnets, and cranesbill afforded valuable cover. The majority of the plants became available as cover between June 1 and September 1, but grasses, such as Dallis grass, Johnson grass, and wild millet, were utilized as late as November 1.

The ragworts, fleabane, pinewoods coneflower, and false-indigo were of chief importance as cover, and were available between April 1 and July 1. Pinewoods coneflower did not close its season until September 15, and one species, in the April wave, bitterweed, continued active until December 1.

The gauras, oaks, horsenettle, white horsenettle, buffalobur, black nightshade, mustang grape, poison-ivy, mesquite, sida, and trumpetvine furnished both cover and seeds for the quail. Their seeds were available between June 1 and December 15, the majority being disseminated from July 1 to November 1. Two species, yaupon and deciduous holly, produced fruit the entire year. All the plants in this group were available as cover from May 1 to January 1, and yaupon and post oak provided cover the entire year. The former was of special importance where it had been bent over so that its branches touched the ground.

For the majority of the spring plants the growing period was longer than any

of the other activity-phases, with the season of blooming next longest, followed by that of maturing seeds. The period of seed dissemination was the shortest of all for most of the species and, from the standpoint of food value to bob-white quail, the most important.

*Summer Flowering Plants.* Summer plants began flowering in June. Strangely enough, while this group had fewer representatives than any of the others, it was possibly more important in producing quail food than all others combined. The summer group embraced two short waves of blooming, one in June, the other in July. All the summer flowering plants extended their activity-phases through the fall and early winter months. Had it not been that their period of blooming was in summer, they could not have been distinguished from the fall plants.

In the first (June) summer wave were French-mulberry (*Callicarpa americana*), partridge-pea (*Chamaecrista fasciculata*) and sunflower (*Helianthus angustifolius*).

The second, or July wave, was composed of three species of crotons (*Croton capitatus*, *C. monanthogynus*, and *C. texensis*), bindweed (*Ipomoea caroliniana*) and knotweed (*Polygonum acre*).

There were five species in the summer flowering group valuable to quail primarily for their seeds. These species were partridge-pea, knotweed, and the three crotons. The seeds of knotweed were available between September 15 and October 15. Partridge-pea disseminated seeds between September 1 and December 15. The remaining summer flowering plants of value for their seeds were available between September 1 and November 1. Most of these plants afforded cover from July 1 to November 1. Of the summer flowering group the three species of crotons exhibited the longest series of activity-phases. Their period of growth was of four months' duration, but the last phase, dissemination of seeds, continued only through about the latter half of November. The crotons had the shortest periods of dissemination of any of the plants observed. Stands of croton were greatly increased when the ground was plowed.

Evidently the length of the period of dissemination of a plant is not always in proportion to its importance to the bobwhite, for the seeds of *Croton*, although disseminated within a short time, may be a staple quail food supply, under normal conditions, throughout not only the winter season but the entire year. Unless eaten, the seeds remain for months on or close to the surface of the ground, affording a food supply of greater or less dependability in the critical winter and spring months and probably to a lesser extent through the rest of the year.

Sunflower seeds were consumed principally by sparrows, and in this locality seemingly were of little or no value to the quail. Sunflower plants were not very useful as cover either, on account of their sparse growth.

*Autumn Flowering Plants.* There was but one wave of autumn plants and it commenced flowering in September.

Included were:

*Amphiachyris dracunculoides*—broomweed
*Andropogon scoparius*—prairie beardgrass
*Andropogon saccharoides*—silver beardgrass
*Aster exilis*, *A. squarrosus* and *A. vimineus*—asters
*Erigeron canadensis*—horseweed
*Heterotheca subaxillaris*—camphor weed

*Ambrosia psilostachya*—perennial ragweed
*Ambrosia trifida*—giant ragweed
*Amaranthus hybridus*—pigweed
*Aristida oligantha* and *A. intermedia*—three-awns
*Chenopodium album*—lambsquarters
*Eleusine indica*—crowfoot grass

Species chiefly valuable as cover were broomweed, prairie beardgrass, silver beardgrass, the asters, horseweed, camphor weed, and the three-awns, all of which were available between September 1 and December 1. The generous flowering habit of the asters and camphor weed rendered these plants especially useful as cover. They attained the peak of flowering in October, which month, incidentally, marked the height of blooming for all fall plants. Many times bob-whites were observed to seek refuge beneath their ample foliage.

Valuable both as food producers and for cover were giant ragweed, pigweed, lambsquarters, and crowfoot grass. Most of their seeds were disseminated in November. They were available as cover between September 1 and December 20, but they were most effective, because most dense, between October 1 and December 1.

The plant of this group valuable for its green food, seeds, and cover was perennial ragweed, which was present almost the entire year. Initial stages of growing were recorded for this species in every month. Through December, January, and February bob-whites were observed feeding upon the foliage of the young sprouts. Seeds of perennial ragweed were disseminated from November 15 to December 20, and the plant was available as cover from September 1 to December 20.

The growing period of the fall flowering plants lasted longer than any activity observed for the plants flowering in winter, spring, or summer; but the period of seed dissemination was shortest. During September the fall species were primarily valuable to the bob-white as cover.

## SUMMARY

1. Weekly field observations made at College Station, Texas, between September 1, 1936 and April 1, 1938, disclosed seven distinct waves of vegetation, segregated on the basis of the period of flowering, and occurring in winter, one wave; spring, three; summer, two; and fall, one.

2. Restriction of activity by season may be due to avoidance of competition. Since the periodic activities of the plants—growing, blooming, seed maturing, and seed dissemination—occur at different times, a considerably greater number of species can be accommodated than if all were similarly active at the same time. In this locality of mild climate the plants divide up the year among them, a fact that is of the utmost significance to such species as the bob-white, with year-long needs for food and cover.

3. While the plants flowering in spring were most numerous, they were not of most importance as food sources for the quail. In fact, the small group of species flowering in the two waves of summer plants appears to be by far the most important for the entire year. These include the partridge-pea, three kinds of crotons, and the knotweed.

4. While the crotons had the shortest periods of seed dissemination of any of the plants observed in all the seasons, they are of outstanding food impor-

tance, as the seeds remain available for months on or close to the soil surface.

5. Close analysis of the periods of growth, blooming, seed maturing, and seed dissemination of all the game food and shelter plants of an area affords a good basis for management as successful management must insure an adequate year long supply of food and cover plants, with special attention to critical periods.

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Tandy P. Chenault
City Schools
Versailles, Kentucky

# WINTER OBSERVATIONS ON PHEASANTS IN SOUTHEASTERN MINNESOTA

*Urban C. Nelson*

In Minnesota, deficiencies in food and cover, resulting in a high winter mortality, are most generally believed to be the limiting factors in the management of the ring-necked pheasant (*Phasianus colchicus torquatus*). This is not conclusively established by scientific evidence, but there are numerous records of high winter mortality resulting from exposure and lack of food or a combination of these and other factors. High mortality can be assumed to be directly traceable to a weakness in the environmental essentials of food and cover and their distribution, since the occurrence of serious predation, disease, or other decimating factors is unusual.

The present analysis is the result of winter observations on pheasant activity in the Deer-Bear Creek Soil Conservation Demonstration Area at Spring Valley, Minn. Observations were made from December 1 to April 1 each year for 3 years (1936–39).

The mere presence or absence, the abundance or scarcity, of a mobile species during winter in a given environment can be considered a strong indication of the merits of that environment in meeting the seasonal needs of the species. Census figures for the demonstration area reveal a population of only one bird per 250 to 300 acres during the period of study. It is improbable, therefore, that crowding seriously restricts mobility; hence choice of certain areas for winter habitation is more likely the result of their providing satisfactory food and cover.

## Description of Area

The Deer-Bear Creek watershed is a 50,000-acre tract comprising the headwaters of the middle branch of the Root River Valley, 80 miles west of its junction with the Mississippi. The topography varies from a level, poorly drained prairie on the west to a rolling to steep area on the east. The soil ranges from a glacial prairie, on the west, to a loessial forest, type on the east. The native tree growth consists of mixed hardwoods, largely red oak, white oak, aspen, basswood, elm, and maple. General livestock and dairy farming is practiced over the area, where the farms average 134 acres. Land use is divided as follows: 65 per cent in crops (corn, grain, rotation hay), 26 per cent in pasture, and 9 per cent in permanent hay, woods, or other use.

## Field Procedure

Field observations were made and recorded at the time on all essential conditions. Most of them were made incidentally to establishing soil conservation practices including farm planning, woodland and wildlife surveys, censusing, feeding station maintenance, and general field supervision. These activities covered a fair cross-section of the entire area and all parts of the farms, including woodland and wildlife areas, pastures, cropland, and farmsteads.

The date, time, species, sex, number, location, weather, and activity were recorded together with other information acquired at each observation. The dates

TABLE 1

DISTRIBUTION OF OBSERVATIONS THROUGH THE WINTER MONTHS 1936-39

| | *December* | | *January* | | *February* | | *March* | |
|---|---|---|---|---|---|---|---|---|
| | 1–15 | 15–31 | 1–15 | 15–31 | 1–15 | 15–29 | 1–15 | 15–31 |
| Number of Pheasants | 57 | 4 | 23 | 61 | 165 | 89 | 34 | 15 |

were from November 25 to March 29 (Table 1) and the time varied from 6:00 A.M. to 5:00 P.M.; most of the recordings were between 9:00 A.M. and 4:00 P.M. (Table 2). The weather varied from −28° Fahrenheit to +48° with an average temperature of about +21° during the period of study. Observations were made with no specific purpose except to gather the existing facts.

TABLE 2

SPREAD OF OBSERVATIONS DURING THE DAY

| | A.M. | | | | | | | P.M. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hour | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 |
| Number of Pheasants | 2 | 4 | 5 | 56 | 65 | 41 | 12 | 17 | 64 | 94 | 64 | 24 |

## ANALYSIS

Such data as date, time, sex, number of birds, location, and weather were a matter of simple recording and summarization. The influence of man was avoided insofar as possible by eliminating observations made from cars, at feeding stations, or under other unnatural conditions. Observations were classified as to activity of the bird, whether feeding, roosting, resting, or cruising (Table 3).

TABLE 3

OBSERVATIONS ON PHEASANT ACTIVITY DECEMBER TO MARCH, 1936–39

| *Activity* | *Number of pheasants* |
|---|---|
| Feeding | 210 |
| Resting in cover | 137 |
| Roosting | 86 |
| Cruising | 15 |

The facts of each incident were the basis for assigning a primary and secondary reason for the bird's presence at the particular location (Table 4). For example, if a bird was seen feeding in a cornfield adjacent to a patch of brush, the food was regarded as the primary factor and the cover as secondary; or, if a bird was seen resting in a windbreak, adjacent to a livestock feedlot, the cover was assigned as the primary, and the food as the secondary factor. Naturally the human element in this assignment can be questioned; however, errors of judgment were minimized by considering each incident individually and simultaneously with knowledge of the contributing environment and activity of the birds in question. Correlation with crop and stomach analysis of the birds might have added much to the accuracy of assignments, but it was not undertaken.

## TABULAR SUMMARY OF OBSERVATIONS

Period of observations: November 25 to March 29 (1936–39, Table 1)

Time of observations: 6:00 A.M. to 5:00 P.M. (Table 2)

Weather: from −28°F. to +48°F. (Approximate average temperature at time of observations, +26°F.)

Number of birds: 448 (130 males, 154 females, 164 sex not recorded)

Frequency of single males: 44

Frequency of single females: 26

TABLE 4
FOOD AND COVER FACTORS ACCOUNTING FOR THE PRESENCE OF PHEASANTS IN PARTICULAR ENVIRONMENTS DURING THE CRITICAL WINTER MONTHS 1936–39

| Types of food and cover influencing occurrence of birds | Importance of food and cover types as primary and secondary factors | |
|---|---|---|
| | Primary (Number of birds) | Secondary (Number of birds) |
| *Food* | | |
| Corn, standing or shocked | 73 | 40 |
| Barnyard strawstacks, grain, manure | 26 | 91 |
| Weeds, annual growth, uncut grains | 26 | 8 |
| Manure in fields, spread or piled | 23 | 0 |
| Shrubs and vines | 2 | 4 |
| *Cover* | | |
| Farm windbreaks, usually coniferous | 88 | 92 |
| Brush, woody shrubs and hardwood reproduction | 41 | 56 |
| Lowland, marsh or meadow | 25 | 40 |
| Woods, oak and other hardwoods | 20 | 27 |
| Mature willow hedges, fence rows | 16 | 0 |
| Weeds, annual growth, uncut grains | 15 | 10 |
| Uncut sweet clover, other legumes | 13 | 0 |

Largest number of males in mixed flock: 7

Largest number of females in mixed flock: 11

Largest number of males in all-male flock: 4

Largest number of females in all-female flock: 6

Largest flock, mixed: 17

The outstanding frequency of occurrence of single males emphasizes their nomadic tendencies during the winter. Individual cocks were often observed in remote locations void of suitable food and cover, but single females were seldom noted in places where other birds were not near and where there was a lack of food and cover. The cock-hen ratio in flocks of more than four birds was 1:1.73 and the ratio in the total number of birds observed was 1:1.14. The presence of the larger flocks was readily correlated with food and cover factors.

The value of corn as food has been generally recognized and this grain is probably of great importance in the more heavily populated pheasant ranges in western Minnesota where more corn is matured and a smaller percentage is cut for silage. The dependence of pheasants on barnyard strawstacks, waste grain, and manure for food, however, has not been so generally recognized. The farmstead does not appear to be a suitable environment because of the presence of cats, dogs, and stock, but these unfavorable elements can not keep the birds away from vitally needed food and cover. The insignificance of shrubs and vines in providing food, apparent in this study, is perhaps largely the result of the scarcity near Spring Valley of such plants with abundant and persistent fruit. Stomach and crop analysis might reveal greater use of natural foods. No attempt was made to determine the

palatability of foods in each type or their relative importance in sustaining life. The value of manure piles, and barnyard residues spread or piled in the field as shown by these observations should not be overlooked in winter feeding in similar areas. The fact that these residues afford some warmth and a resting spot free of snow may account in part for the birds' use of them.

The data on utilization of cover (Table 4) show the extent to which pheasants frequent windbreaks, brush, meadow, woods, mature willow hedges, weeds, and uncut legumes. The importance of farm windbreaks for winter cover is revealed by these data and by many unrecorded observations. Since the majority of records were made during full daylight, the observations on roosting were relatively unimportant. It is generally believed that the lowland marsh or meadow is of great importance as cover on heavily populated pheasant ranges.

In the locality here reported upon, brush is more frequented than woodland primarily because of its proximity to the food supply on the cultivated areas. The combined value of woods and brush in providing cover is comparable to that of windbreaks. Observations tend to indicate a greater use of windbreak cover on level prairie than on rolling wooded land.

## SUMMARY

Deficiency in food and cover resulting in a high winter mortality is considered the limiting factor in the management of ring-necked pheasants in southeastern Minnesota. A field analysis, although based on relatively few observations on range with a low pheasant population, indicates the dependence of the birds on farm windbreaks, corn, and barnyard foods during the winter months. The value of the farm windbreak as cover is great on prairie land where standing corn provides food. Barnyard foods are of most value in areas where brush and woodland cover is available and there is a scarcity of standing corn. Improved management of the ring-necked pheasant should add better winter cover; planting of coniferous and hardwood cover in small areas well distributed over the farm would help.

Feeding seems to be the principal activity of pheasants during daylight hours. Cocks have a nomadic tendency and often travel alone, while hens have a relatively short cruising radius and are more prone to flock.

Urban C. Nelson
Soil Conservation Service
Chillicothe, Missouri

# BLASTING TO IMPROVE WILDLIFE ENVIRONMENT IN MARSHES[1]

*Thos. G. Scott and W. L. Dever*[2]

Numerous investigations have shown the inefficiency of habitats in which the cover type is dense and continuous. The game manager, cognizant of this evidence, has attempted to remove restrictions of habitats by opening them. Many areas wasted because of dense vegetative cover have been improved by clearing operations.

Marshes choked with rank growths of emergent vegetation are a monotonous cover type subject to such improvement. McAtee's (1939) discussion of blasting as a means of creating duck ponds suggests a technique for improvement of marshes.

The authors here report on the experimental use of dynamite as a means of opening up stands of marsh vegetation. This work was carried out during the summer of 1939 at Little Wall Lake, a 230-acre marsh near Jewell, Iowa, grown up to a dense *Scirpus-Typha* (bulrush-cattail) community.

In planning procedure, consideration was given to the edge-effect desired and to the economical use of dynamite. It was decided that a ditch, 9 to 12 feet wide and 3 to 4 feet deep would meet the requirements.

The location and direction of the excavations were selected so as to provide desired wave action in the completed ditch. The site was cleared of vegetation with a brush hook, to facilitate the work of the loading crew. The use of plank walks in "soupy" parts of the marsh also aided materially, especially in connection with the clearing of vegetation and the transporting of dynamite.

The blasting was done by the propagation method in which the explosion of a single charge detonates all the others, thus eliminating the cost of capping each individual load. This method may be effectively employed only in wet soils. A straight row of charges was insured by following a line stretched along the proposed site. Charges were placed at 18-inch intervals where there were less than three cartridges to a place, and at 24-inch intervals for heavier charges.

Loading tools such as the T-punch bar and T-core punch bar were available, but it was found that a broom handle notched at 12 inch intervals could be used very efficiently in punching and loading holes in the soft, wet soil.

The size of charge was governed by the depth of soil and water above the surface of the hardpan. Loads of one stick were used for 2.5 feet, 2 sticks for 3.5 feet and 3 sticks for 4.5 feet of soil and water, respectively. Heavier charges were not tried. Best results were obtained where the bottom cartridge of each charge rested upon the hardpan.

[1] Journal Paper No. J-731 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 496. Iowa State College, Iowa State Conservation Commission, and American Wildlife Institute cooperating with the U. S. Biological Survey.

[2] Credit is due Edwin Snead, Iowa State College, and F. C. Ziesberg, E. I. DuPont de Nemours and Company, for technical assistance with these experiments.

It proved advantageous to blast during strong winds as the debris lifted was blown away and did not fall back into the excavation. Accordingly the blasting proceeded with the wind so that the soil from successive blasts was blown clear.

The result of a properly placed blast in muck and peat was a ditch 9 to 12 feet wide (Plate 12A). Any desired length may be had, but it is not efficient to shoot more than 300–400 feet at a time. Shoulders were thrown up on either side ranging from one to six feet wide and from one to three feet high (Plate 12B). The depth of the ditch when blasted over hardpan was limited to the distance from the water surface to that of the hardpan.

Excavations were attempted in deep muck and peat with the same method used over hardpan except that the top of the upper stick of each charge was set about one foot below the water surface. These results were practically worthless. A single-line placement with 2- and 3-stick charges was tried in muck and peat known to be over 10 feet deep. The result (Plate 13) was a narrow ditch (7 to 8 feet) with low shoulders and "soupy" with powdered peat. The explosion seemed to have been so effectively cushioned that it had but little lifting power. However, in locations where running water could be directed through the channel it could be sluiced out.

The cost of materials and labor varied with each type of excavation. Ditches were made in the experimental work here discussed at a cost of about 14 cents a cubic yard. However, this can hardly be considered representative of costs on large projects where materials could be obtained at wholesale prices. For estimating costs on such projects the following information may prove helpful. In these experiments a two-man crew excavated approximately 100 feet of ditch an hour. The size of charge varied with the requirements of each blast, but only one cap was needed for each blast when the propagation method was used.

Successful application of the blasting technique here described is largely limited to marshes having a hardpan sub-stratum. However, the conclusion should not be drawn that dynamite cannot be satisfactorily employed in opening up other types of marshes. It is probable that further experiments will result in such modifications of the technique as to make it applicable to the more difficult situations.

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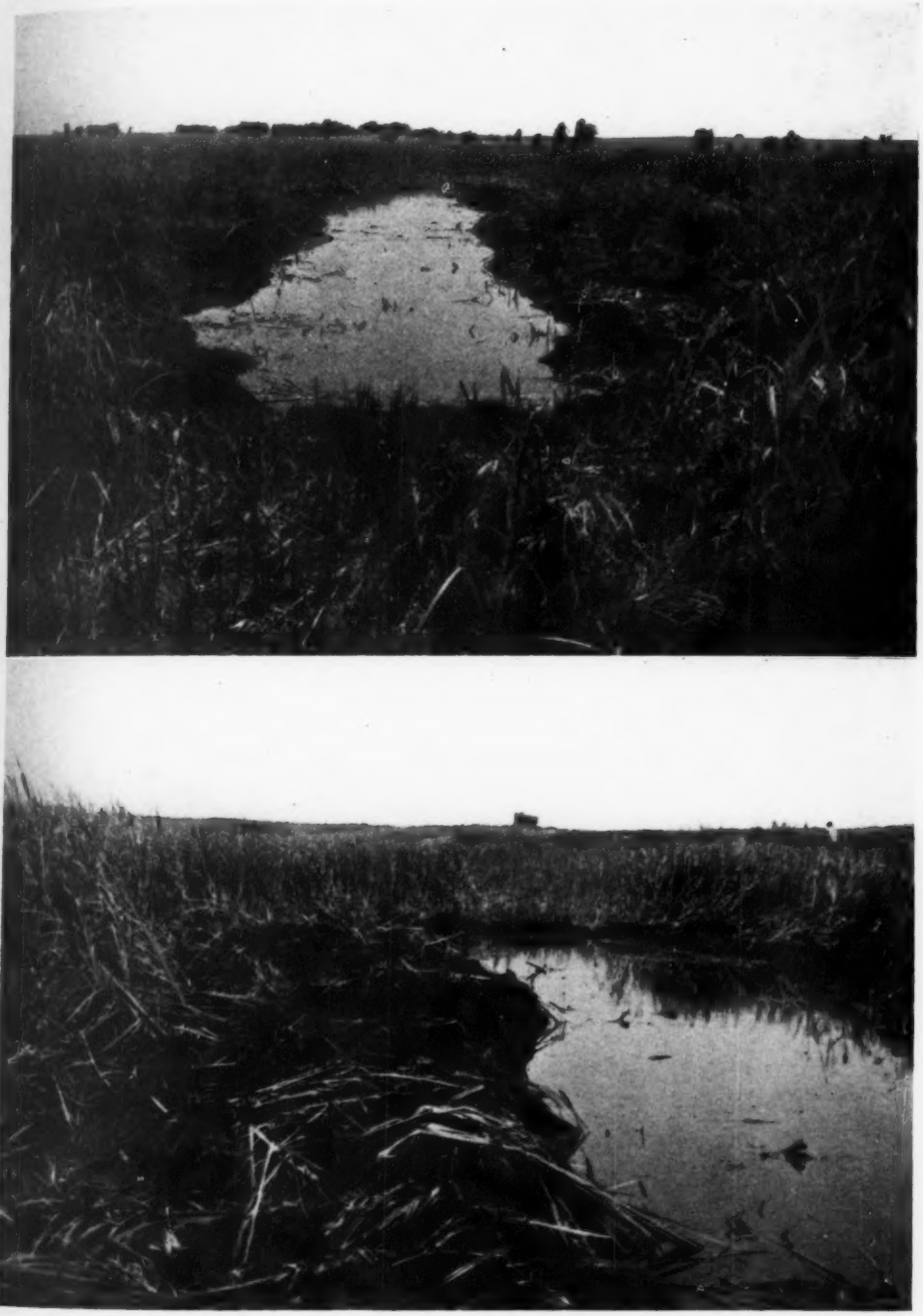
Thos. G. Scott
U. S. Biological Survey
Iowa State College
Ames, Iowa

W. L. Dever
E. I. DuPont de Nemours & Co.
1245 34th Street
Des Moines, Iowa

A
B



A (*Upper*)—Ditch ten feet wide, three to four feet deep, blasted over hardpan.

B (*Lower*)—Shoulder on a ditch blasted over hardpan.

Ditch blasted in deep muck and peat. Note narrowness and absence of raised shoulder.

# FOOD HABITS OF THE RACCOON IN EASTERN IOWA[1]

*LeRoy W. Giles*[2]

In the course of studies concerning the ecology of the raccoon (*Procyon lotor*) in eastern Iowa, during the spring, summer, and fall of 1938, a collection of scats was made for the purpose of determining the local food habits of the animal. Though the work included only a 9-month period, the record obtained may be considered as representing the entire year for the winter season is normally one of comparative inactivity when little food is taken or required. The total collection consisted of 363 scats and 2 stomachs. These were analyzed by the volumetric method supplemented by a count of the number of insects and other animals represented in the fecal material.

The area covered in the investigation consisted of about 21 square miles of hilly country, in the vicinity of Durango in northeastern Dubuque County. Through this territory flow several small branches of the Maquoketa River which include, altogether, about 18 miles of stream. A considerable proportion of the area is wooded, with the timber confined largely to the steeper hillsides. One conspicuous feature of the rough topography is the presence of many prominent limestone outcrops along the streams and eroded valleys. These rock bluffs form a significant part of the raccoon habitat as most of the denning is in their numerous cracks and fissures.

The narrow valley bottoms are either pastured or in cultivation which is also true of the naturally flattened hilltops. Dairying and swine production are the principal farm industries. These necessitate the extensive cultivation of grains—a type of farming well-suited to the food requirements of the raccoon. Corn, especially, is known to be one of the most important of raccoon foods.

The scats were found in a number of places but for the most part were picked up on the higher ledges and rims of the bluffs where a large part of the defecation apparently occurred. Fully 77 per cent of the scats were found associated with these rocky prominences. Only 17.5 per cent were picked up along the streams, at the bases of trees, or on logs or piles of brush and other debris. Occasionally scats were dropped in pastures, woods, or dirt roads. Such promiscuous defecation seemed more prevalent in the spring and early in summer than later in the year and probably accounts to a certain extent for the smaller number of scats collected during the earlier months. Several of the fecal samples were taken from the passages of abandoned lead mines. These tunnels undermine several

[1] Journal paper No. J 735 of the Iowa Agricultural Experiment Station. Project No. 566. Iowa State College, Iowa State Conservation Commission, and American Wildlife Institute cooperating with the U. S. Biological Survey—a modification of thesis material presented to the graduate faculty of Iowa State College in compliance with the requirements for the degree of Master of Science.

[2] Grateful acknowledgment is made of supervision by Dr. G. O. Hendrickson, Iowa State College, and T. G. Scott, U. S. Biological Survey.

of the hills in the central part of the area and would undoubtedly have proved even more important collecting sources had they been safe and easily accessible. Some of the mines had long been used for denning and contained many scats.

All of the fecal samples were examined closely in order to avoid any possible chance of getting scats from other animals, and the material from any scats of doubtful origin was discarded. Typical raccoon feces are not hard to identify; they possess a distinctive shape, are usually larger than the scats of other animals with which they are likely to be confused, and frequently the fecal contents as well as the places of defecation are indicative. Some of the scats of uncertain origin could be classified by odor. Fresh raccoon scats have a characteristic, though rather indefinable, odor which varies with the type of food and can only be learned through experience. The presence of stray raccoon hairs was also considered as proof that the scats were from raccoons.

The food habits data for the 9 months can well be considered according to 4 periods defined by noticeable changes in diet and each distinguished by one or more characteristic foods. The first of these is a post-winter period that began shortly before the start of collecting and was a time of marked corn consumption. This was followed by a later spring period during which grass and beetles were predominating foods. The ripening of wild raspberries marked a third change in food that lasted through the early summer. The final dietetic interval was the longest, including late summer and the entire fall. Like the first period it was distinguished by a notable preference for corn. The dates which delimit these periods are, of course, not strictly accurate but are determined by those when the scats were found. However, since only comparatively fresh scats were collected the divisions are reasonably dependable.

The post-winter period is based on the contents of six scats which were picked up between March 23 and April 16. Three of these were found on rock bluffs while the other three came from a mine tunnel that was utilized as a den at the time. All six scats contained corn which formed the bulk of all but one scat and constituted 78.99 per cent of the total fecal volume for the period. The chitinous remains of two crayfishes (*Cambarus*) made up most of the exceptional scat and formed 15.09 per cent of the total volume. Two of the scats contained remains of three vertebrates (2 unidentified birds and 1 cottontail *Sylvilagus floridanus mearnsi*); however, these were present in small quantities and composed only 5.53 per cent of the volume. Other foods were represented as traces: insects in 3 scats (see Table 1 which includes a list of the different insects eaten throughout the entire 9-month collecting period), smartweed seeds (*Polygonum*) in one, and clover seeds (*Trifolium*) in one.

The feces for the period was composed of 79.12 per cent plant, and 20.88 per cent animal, material by volume.

Between April 19 and June 20, 41 scats were collected. Grass and insects comprised the bulk of the material in these scats, with grass having somewhat the larger volume. Though the

TABLE 1

A LIST OF THE INSECTS TAKEN FOR FOOD

| Species | Number of individuals | | | |
|---|---|---|---|---|
| | Period | | | |
| | First | Second | Third | Fourth |
| Orthoptera (total) | | 4 | 42 | 766 |
| Phasmidae (total) | | | | 4 |
| Diapheromera sp. | | | | 4 |
| Tettigonidae (total) | 1 | | 1 | 17 |
| Amblycorypha sp. | | | | 1 |
| Conocephalus sp. | | | | 4 |
| Orchelimum sp. | | | | 6 |
| Scudderia strigata | | | | 1 |
| Locustidae (total) | | 4 | 41 | 731 |
| Arphia sp. | | | 1 | |
| Chortophaga sp. | | | 1 | |
| Dissosteira carolina | | | 1 | 1 |
| Melanoplus bivittatus | | | | 2 |
| M. differentialis | | | 8 | 193 |
| M. femur-rubrum | | 2 | 29 | 528 |
| Gryllidae (total) | | | | 13 |
| Gryllus sp. | | | | 1 |
| Gryllus assimilis | | | | 12 |
| Neuroptera (total) | | | | 51 |
| Corydalus cornutus | | | | 49 |
| Hemiptera (total) | 3 | 3 | | 4 |
| Belostomatidae (total) | | 1 | | |
| Benacus griseus | | 1 | | |
| Pentatomidae (total) | 3 | 2 | | 4 |
| Acrosternum hilaris | 3 | 1 | | 3 |
| Menecles insertis | | 1 | | |
| Coleoptera (total) | 3 | 545 | 402 | 217 |
| Carabidae (total) | | 117 | 159 | 174 |
| Anadaptus discoideus | | | | 3 |
| Anisodactylus verticollis | | | | 1 |
| Brachynus alternans | | | 2 | 1 |
| Calosoma calidum | 1 | 41 | 42 | 1 |
| C. externum | | | 1 | 2 |
| C. peregrinator | | 3 | 2 | |
| C. scrutator | | 9 | 4 | 1 |
| Carabus serratus | | 3 | 2 | |
| C. sylvosus | | 10 | 18 | 48 |
| Chlaenius sp. | | 2 | 1 | 8 |
| C. diffinis | | 1 | 3 | |
| C. sericeus | | 1 | | |
| C. tomentosus | | 6 | 1 | |
| Dicaelus splendidus | | 4 | 2 | 5 |
| Evarthrus sp. | | | 1 | |
| Galerita janus | | 5 | | 5 |
| Geopinus incrassatus | | 1 | | 1 |
| Harpalus caliginosus | | 1 | 19 | 13 |
| H. erraticus | | 1 | | 23 |
| Pasimachus elongatus | | 2 | 3 | 3 |
| Patrobius longicornis | | | | 1 |
| Pterostichus sp. | | 2 | 1 | 4 |
| P. obscurus | | 2 | 2 | 3 |
| Scarites substriatus | | | 3 | 1 |
| Cerambycidae (total) | | | 1 | |
| Parandra brunnea | | | 1 | |

TABLE 1—*Continued*

| Species | Number of individuals | | | |
|---|---|---|---|---|
| | Period | | | |
| | First | Second | Third | Fourth |
| Carabidae—*Continued* | | | | |
| Cicindelidae (total) | | 2 | 1 | |
| Cicindela sexguttata | | 2 | 1 | |
| Dytiscidae (total) | | | 1 | 3 |
| Dytiscus fasciventris | | | 1 | 2 |
| Hydrophilidae (total) | | 1 | | 1 |
| Tropisternum sp. | | | | 1 |
| T. nimbatus | | 1 | | |
| Lucanidae (total) | | 23 | 20 | |
| Dorcus parallelus | | | 1 | |
| Lucanus dama | | 23 | 18 | |
| L. placidus | | | 1 | |
| Scarabaeidae (total) | | 396 | 202 | 4 |
| Canthon sp. | | | | 1 |
| Copris anaglypticus | | 26 | 5 | 1 |
| Phyllophaga spp. | | 370 | 197 | 2 |
| Silphidae (total) | | 4 | 2 | |
| Necrophorus sp. | | 1 | | |
| N. orbicollis | | 2 | 2 | |
| Silpha inaequalis | | 1 | | |
| Tenebrionidae (total) | | | 1 | |
| Nyctobates pennsylvanicus | | | 1 | |
| Lepidoptera (total) | | 304 | | |
| Nephelodes emmedonia | | 303 | | |
| Hymenoptera (total) | | 8 | 6 | 191 |
| Bombidae (total) | | | | 10 |
| Bombus sp. | | | | 10 |
| Vespidae (total) | | 7 | 6 | 178 |
| Polistes sp. | | 7 | 6 | 178 |

grass was evidently eaten in considerable quantities it was only partially digested—a fact accounting to some extent for its volumetric importance. It probably acted as a tonic food or roughage and was not consumed for nourishment alone. Grass was found in nearly half or 46.34 per cent of the scats while its volume was 37.09 per cent of the total. The insect remains recovered were principally those of May beetles (*Phyllophaga*), bronzed cutworms (*Nephelodes emmedonia*, which occurred only in the grass containing scats), and carabids, chiefly of the genus *Calosoma*. Insects formed 35.07 per cent of the total volume and appeared in 97.56 per cent of the scats.

An item seemingly out of place for this season of the year, was hickory nuts. Most of these were from the shellbark hickory (*Carya ovata*) which is the common species of the locality. The crushed shells of these nuts constituted 11.45 per cent of the total volume and were found in 12.19 per cent of the scats. Though hickory nuts rank third in quantitative importance, the bulkiness of their shells gives them undue significance and according to the actual nourishment furnished, they probably rank lower.

The remains of 17 crayfishes appeared in the feces, and they were

proportionately of more importance in this period than at any other time of the year. They constituted 7.56 per cent of the entire volume and were present in 29.27 per cent of the scats.

Corn continued to show up in small amounts. It was found in 31.71 per cent of the scats, though it measured only 5.07 per cent of the total food remains.

A variety of vertebrates were eaten, and their remains appeared in 21.95 per cent of the feces. The hair and bones of a fox squirrel (*Sciurus niger rufiventer*) made up 94 per cent of one scat, otherwise, the vertebrate material was present in such small quantities that, altogether, it measured only 2.60 per cent of the total volume. The remains consisted of two fishes (one a centrarchid, probably *Apomotis cyanellus*), one frog (*Rana*) and an unidentified amphibian, two unidentified snakes and a species of the family Colubridae, two undetermined birds, and an unidentified vertebrate.

A considerable number of fishes were known to have been eaten on two occasions which are not indicated in the collected fecal material. The fishes became available when the streams rose during severe storms and left them stranded on the banks or in puddles in ditches and other low spots. In one instance a raccoon ate approximately 30 small fishes, including minnows, sunfishes, and suckers, from a shallow pool in a single night. In the pool, also, were nearly as many tadpoles that were not touched. For several weeks following this incident, tracks of the raccoon could be found after every rain in the ditch that had contained the pool.

Fragments of gastropods formed 0.82 per cent of the fecal aggregate. These included 8 small aquatic gastropods and five land snails (*Polygyra*) and were present in 21.95 per cent of the scats.

Various incidental inclusions, with or without apparent food value, occasionally appeared. Traces of acorns occurred 3 times; 5 millipeds (*Julus*) were found in one scat; wads of cowhair were noted twice; and the skins and seeds of gooseberries (*Ribes*), dogwood berries (*Cornus*), unidentified seeds, and wood fragments each appeared once.

The plant and animal food remnants were more nearly equal in volume for this period than in the first division. Plant food formed 53.75 per cent of the total, and animal food 46.25 per cent.

Seeds of wild raspberry were a distinctive feature of the summer scats. The vines of both the black (*Rubus occidentalis*), and to a lesser extent, the red (*R. strigosus*), raspberries were abundant, especially on the open hillsides, and their fruit was consumed in large quantities. From June 20 to Aug. 11, 44 scats were found, and of these, 54.54 per cent contained raspberry seeds in amounts sufficient to make up 32.17 per cent of the entire fecal volume.

Insect consumption continued at a high level until the middle of July, remains of these invertebrates forming 25.5 per cent of the total volume. Beetles were by far the most important group making up 96.93 per cent of the insect food. Grasshoppers and a few Polistes wasps represented the remainder. Bronzed cutworms appar-

ently had ceased to be available for none were found in the feces for this period. Insects were included in 93.18 per cent of the scats.

Corn was still occasionally picked up. It formed 13.07 per cent of the entire volume and occurred in 20.45 per cent of the feces.

Gooseberry bushes grew profusely on the area and fruited heavily. They were much more common than the raspberries, and their presence on the bluffs and along the streams seemingly made them the more readily available of the two. Yet their berries ranked much lower in preference. Their fecal remains formed 12.65 per cent of the entire volume, and, as their skins as well as their seeds were indigestible, this total represents even a smaller volume of food than an equal amount of raspberry remains. Gooseberries occurred in 30.00 per cent of the scats.

Vertebrate remnants comprised 4.35 per cent of the total volume, though they appeared in 34.10 per cent of the droppings. The forms represented included 2 unidentifiable fishes, a bullsnake (*Pituophis sayi*), 4 birds, 1 of which was a woodpecker (*Dryobates*), 1 prairie mole (*Scalopus aquaticus machrinus*), 2 deer mice (*Peromyscus*), 1 field mouse (*Microtus*) and an unidentified mouse, 1 squirrel (*Sciurus*), 1 raccoon, 1 unidentified mammal, and 3 unidentified vertebrates.

The raccoon remains made up nearly an entire scat and reflected the only case of cannibalism found. An adult raccoon, probably a male, ate a young raccoon about a month of age. The writer handled this young animal and released it at the den in a bluff only a short distance from where it was eaten. The den was immediately abandoned and presumably the young raccoon was deserted. Whether it starved to death or was killed could not be ascertained.

A few hickory nuts were eaten in the early part of this period. They occurred in 3 scats and formed 3.77 per cent of the fecal volume. The seeds of wild strawberries (*Fragaria*) were taken from 3 scats and constituted 1.36 per cent of the total volume. Strawberry plants were not common in the locality and were seldom found bearing fruit.

Included in the scats also was a considerable variety of items of insignificant quantity but indicative of a wide range of dietary possibilities. These include: snails (*Polygyra*) in 4 scats with a total of 4 individuals; traces of the nest paper of Polistes wasps in 3 scats; wild cherry (*Prunus*) seeds in 2 scats; wads of cattle hair in 2; and in 1 scat each acorn hulls, bits of limestone, seeds of foxtail (*Setaria*), seeds of cultivated plum, wild grape, unidentified seeds, a small amount of apple, grass, and 1 spider egg sac.

The total volume of feces was composed of 69.36 per cent plant material and 30.64 per cent animal remains.

The data for the final period are based upon 272 scats and two stomachs collected Aug. 11–Dec. 7. This period began when the field corn reached the "milk" stage and continued throughout the fall. Corn became an increasingly important food as the season advanced and toward the last was eaten almost exclusively. It occurred in 87.87 per cent of the scats and formed 85.19 per cent of the total volume of fecal material. Further investigations indicate that this heavy consumption of corn may have been due, in part, to a

scarcity of other foods, particularly wild fruits, and should not be attributed to preference alone.

Insects were eaten during the entire period, but, except for a short time from the last of September to the middle of October, they appeared only as traces in the feces. They comprised 10.06 per cent of the total volume and were found in 84.56 per cent of the droppings. Grasshoppers formed the important insect food of this time and included 93.18 per cent of all the insects eaten. Of less importance were carabids, particularly *Carabus sylvosus*, Polistes wasps, and hellgrammites (larvae of *Corydalus cornutus*).

Occurring in 11.40 per cent of the scats were crayfish remains. They formed 2.07 per cent of the fecal volume. A total of 31 crayfishes was counted.

Remains of vertebrates were found in 14.34 per cent of the scats, though they constituted only 1.21 per cent of the entire fecal volume. In several cases the evidence of vertebrate food was only a splinter of bone or a piece of feather shaft which gave almost no quantitative value. Vertebrates represented were: 1 fish, 1 frog (*Rana*), 1 lizard (*Eumeces*), 3 snakes, 11 small birds (1 a goldfinch, *Spinus t. tristis*), 9 mice, including 5 field mice (*Microtus*) and 3 deer mice (*Peromyscus*), 1 muskrat (*Ondratra z. zibethica*), 1 woodchuck (*Marmota m. monax*), 1 squirrel (*Sciurus*), 3 rabbits (*Sylvilagus floridanus mearnsi*), 1 unidentified mammal, and 4 unidentified vertebrates.

Seeds of *Solanum* appeared in 2 scats. One lot was identified as *S. nigrum*, the black nightshade, and made up one entire scat. These seeds formed 0.56 per cent of the total volume. Of minor occurrence, also, were the seeds and skins of wild grapes (*Vitis*) which appeared in 4 scats and comprised 0.50 per cent of the volume. Wild grape vines were exceedingly common but rarely bore fruit.

Quite a number of miscellaneous inclusions appeared in comparatively minute quantities. Smartweed seeds, largely those of *Polygonum pennsylvanicum*, occurred in 41 scats, though the total volume of seeds recovered measured less than 1 c.c. Gastropods showed up 12 times with 15 individuals represented (12 *Polygyra* sp. and 3 small aquatic gastropods). Greater ragweed seeds (*Ambrosia trifida*) were present as traces in 12 scats. Twenty-one spider egg sacs were counted from 10 scats. Fragments of acorn hulls appeared 8 times. Raspberry seeds showed up in 3 scats in the early part of the period. In each of 2 scats occurred seeds of wild cherries (*Prunus*), ground cherry (*Physalis*), red cedar (*Juniperus virginiana*), lambsquarters (*Chenopodium album*), and 14 larval cocoons of *Bombus* sp. And from 1 scat each were: grass, cattle hair, fragments of poultry egg shell, dogwood berries (*Cornus*), and milliped (*Julus*).

The ratio of plant to animal remains for this period was quite high because of the large amount of corn in the diet. Plant material was 86.58 per cent of the aggregate volume while animal remains constituted only 13.42 per cent. Of the plant substance 98.42 per cent was corn.

The 2 stomachs examined were from raccoons killed on Nov. 15. One of these contained only corn with a

volume of 139 c.c. The other contained 41.5 c.c. of corn, 2 grasshoppers (*Melanoplus femur-rubrum*), and the remnants of a former meal of deer mouse (*Peromyscus*) represented by 10 c.c. of the indigestible fur and bones.

## SUMMARY

1. For the purpose of determining the food habits of the eastern raccoon in Dubuque County, Iowa, 363 scats and 2 stomachs were collected and analyzed. The scats were found, for the most part, on the rims and ledges of limestone bluffs. To a lesser extent they were picked up along the streams, in the woods and pastures, and in tunnels of abandoned lead mines.

2. The food habits data are treated by 4 periods each characterized by one or more distinctive foods. During the first period corn ranked first in consumption and was highly important as a post-winter staple. When other foods became abundant it dropped considerably in preference though it was still available and was eaten to a minor extent throughout the early summer. Again, in the middle of August when the field corn matured, it became the chief food and so continued. Following the first period grass was eaten in large quantities, probably serving as roughage and as a tonic food, then, wild raspberries became available, their seeds replaced the grass as a predominating fecal inclusion. Along with the grass the fragments of large numbers of beetles and cutworms appeared. The cutworms were found in only the grass-containing scats; beetles however, remained an outstanding food until the middle of July. For a time then insects appeared only as traces until about the last of September when grasshoppers became abundant in the feces, so to remain until the middle of October. Vertebrate food remains were present only in small quantities though the frequency indices give them a somewhat greater significance. A wide variety of vertebrates was eaten with no particular group suffering very serious predation.

3. The aggregates of plant and animal materials recovered from all of the scats and the contents of the two stomachs indicate that the raccoons had definitely vegetarian tendencies. Fully 77.73 per cent of the bulk of the feces was of plant origin, whereas, only 22.27 per cent was of animal derivation.

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LeRoy W. Giles
Iowa State College
Ames, Iowa

# SOME OBSERVATIONS ON FARM GAME MANAGEMENT COOPERATIVES IN MICHIGAN

*Russell G. Hill*

This paper concerns the Williamston Plan of game management, but does not deal with its fundamental set-up which is well known. The following statements are based not only upon our observations for the last four years, but also upon experiences of others in these cooperatives during the seven years prior to our entering the work.

When the plan for cooperation with rural communities was first discussed by the State Department of Conservation, it was soon realized that in a Commonwealth with 10,000,000 acres of pheasant range, the movement would enjoy very little success if it could not be applied over a large area at a low unit cost. Realizing further that any successful farm organization must be run by the farmers themselves, these cooperative organizations were encouraged to become as democratic as possible. At present in order for farm communities to get cooperation in setting up their cooperatives and in obtaining all the posting material necessary, the Department requires only three things:

1. That the area be not greater than 10,000 acres.
2. That no charge be made for hunting.
3. That the hunting privilege be not restricted to any special group of hunters.

All other rules and regulations needed for operation of the organizations are made by the farmers who also administer them. It has been observed that the majority of organizations formed through the primary efforts of the Department or of sportsmen's clubs have not been successful. Requests for assistance from the State Department of Conservation must come directly from the landowners. No effort is made to promote these cooperatives among farm people; we await their initiative. Nevertheless growth in number of these organizations has been rapid as indicated in Table 1.

TABLE 1
WILLIAMSTON PLAN COOPERATIVES

| *Year* | *Number of co-ops.* | *Total acreage* | *Average area of co-ops.* | *Number of farms included* |
|---|---|---|---|---|
| 1936 | 1 | 13,000 | 13,000 | 275 |
| 1937 | 34 | 341,271 | 10,271 | 4,768 |
| 1938 | 61 | 440,999 | 7,229 | 5,962 |
| 1939 | 110 | 497,563 | 4,523 | 6,394 |

It will be observed that the average area of the cooperatives has steadily decreased from 13,000 acres in 1936 to 4,523 in 1939. As they were first set up the projects were much too large and farmers did not attend the meetings because they had too far to go. Hence they did not become familiar with the fundamental idea of the cooperative nor with the rules and regulations under which their organization was operating. In addition, on the larger areas game conditions as well as the ideas of the people on administration varied considerably and, as a result, difficulties arose. Accordingly during the last three years we have endeavored to convince communities wishing to form these cooperatives of the desirability of keeping the areas smaller. Thus the average

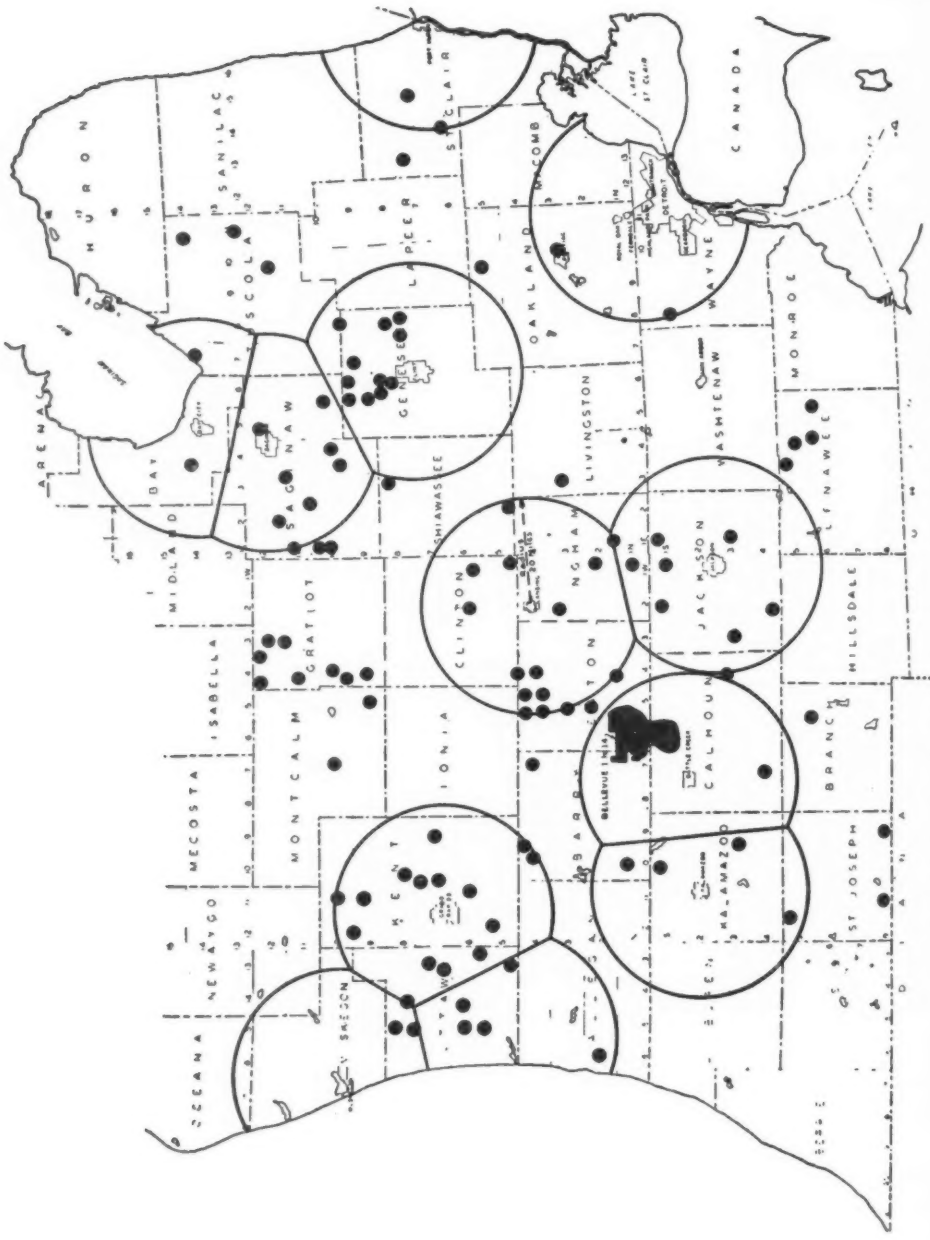


Chart 1. Location of Game Management Cooperatives (Michigan 1939).

Chart 2. Game Management Cooperatives, 1939.

Areas and number of cooperatives in each: I, 20; II, 26; III, 15; IV, 10; V, 9.

Chart 1. Location of Game Management Cooperatives (Michigan 1939).

area, as well as the total acreage, has not increased in proportion to the number of clubs. In fact, we see no reason why farm communities controlling only one or two sections of land should not successfully operate a game management cooperative.

These organizations seem to be most popular where trespass difficulties are greatest. Eighty-four of the 110 are within a 20-mile radius of large municipalities (see Chart 1).

Considering the distribution of the cooperatives by counties it is further apparent that it was problems arising in connection with the harvesting rather than the producing of game that stimulated the formation of these organizations. For this purpose the counties, including the largest concentrations of the game management cooperatives have been grouped in five areas, (see Chart 2). Areas I, II, and III, while they represent only 8 of the 40 counties usually recognized as being good pheasant habitat, include more than half of the cooperatives with which we are working. The large representation of projects in one county designated as an area by itself (V) has resulted from the activities of an unusually interested county agricultural agent. In Area IV while, as indicated, there are only ten game management cooperatives in the eight counties, there are probably twice as many similar organizations operating independently of the State Conservation Department. Most of these independent organizations have some form of paid hunting, while on the State cooperative areas there is no charge. The five groups of counties outlined on the chart include only 42% of the counties in the best pheasant range, but they are visited by 67% of the total number of pheasant hunters who bag 70% of all the birds killed.

Whether fees are charged or not, it is believed that control of the harvest is the primary reason for the existence of these organizations, and very little attention is given to increasing the production of game. If they had been formed for the latter purpose they would have been organized in larger numbers in sections of the state where the pheasant population could well be increased.

It has been said at a few organization meetings that a reason for action was reduction of the illegal kill of game, especially of hen pheasants, but the real motive is frequently difficult to ascertain. A few communities have had the conservation of certain game animals in mind as indicated by some of their special regulations. It has been suspected in a few instances that the cooperative resulted from the initiative of a community leader who desired to have a large hunting area for himself and his friends.

The question arises as to whether the hunting is better because of restriction of the number of hunters. It might be in areas that were overshot before the cooperative was formed but we have no proof of this. Some cooperatives report that there are just as many hunters as ever but that the group is more orderly and less likely to commit mischief. One of the major changes that has resulted from the system and that gratified the farmers is the almost total elimination of hunting by persons parking on roadsides and not coming to the farmstead.

The location of game management cooperatives near industrial centers

presents the farmers with one especially difficult problem. There is an increasing tendency for factory workers to live on one or two acres of land in the country and drive back and forth to work. Their presence in the community as landowners but not as farmers complicates the problems of hunting control. In the first place they are likely to be part of the trespassing public and they may invite friends to go hunting. They own little land so the hunting must be done on that of neighbors. Should they be included in the cooperative? Should they have guest tickets to give out? There have been organization meetings in such localities attended by more of these residents than by *bona fide* farmers. A number of communities with this problem have partially solved it by distributing guest tickets on an acreage basis. Under this arrangement, a resident with from one to ten acres may receive a membership ticket for his own use but no permits transferable to outsiders.

With a considerable number of cooperative organizations involved there has been some mortality. Table 2 records this as well as the number of new clubs formed each year.

Table 3 shows the location of cooperatives that failed in 1938 and 1939 according to the areas numbered in Chart 2.

TABLE 2

| *Year* | *Number of co-ops.* | *Mortality* | *Per Cent* | *New Clubs* |
|---|---|---|---|---|
| 1936 | 1 | 0 | 0 | 33 |
| 1937 | 34 | 12 | 35.3 | 39 |
| 1938 | 61 | 9 | 14.7 | 58 |
| 1939 | 110 | | | |

Thirty-five per cent of the cooperatives operating in 1937 failed to reorganize in 1938 and 14.7% of the 1938 total did not continue in 1939. While decrease in the percentage of mortality is heartening, the question arises, "What has been the cause of the failures?" There is

TABLE 3
LOCATION OF COOPERATIVES INCLUDED IN MORTALITY

| Year | Mortality | Location (Area) | | | | Other |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | |
| 1938 | 12 | 4 | 6 | 1 | 1 | |
| 1939 | 9 | 3 | 2 | | 1 | 3 |

no simple answer to this query, a variety and a combination of causes have been involved. However, the most prevalent reasons are:

1. Failure on the part of the members to adhere rigidly to the rules and regulations which they themselves had made.
2. Failure on the part of landowners to understand the objectives and the working of the organizations.
3. Lack of local leadership.
4. Location of the project adjacent to or interspersed with areas of wild land to which hunters could readily gain access and from which they could easily go into adjacent farm fields.
5. Lack of a solidly blocked area, many farms in the neighborhood not belonging to the cooperative.
6. Lack of harmony between the farmers in a community.

These mortality factors are not peculiar to the game management cooperatives as other types of farm organizations have suffered losses from some of the same defects.

The number of hunting permits available for each farm in the 110 cooperatives ranges from two to five, with an average of about three. Sixty-three of

the organizations allow a guest hunter who has obtained a permit to hunt over all the land controlled by the cooperative. The average size of the tracts is 4,523 acres—far more land than a hunter will walk over in a day. Twenty-two of the cooperatives allow the permittee to hunt over the section of land around the house where the permit was obtained—a large enough area for an individual hunter. Thus the organization materially benefits the hunter by providing a sufficient area for a satisfactory hunt and doing away with trespass difficulties. Twenty of the organizations restrict the hunter to the farm from which the permit was procured and five others have the same requirement unless the member or landowner accompanies him, in which case he is usually allowed to hunt over the entire area.

The desire to limit hunting to a single farm has been due in some cases to uneven distribution of game cover. Where one landowner in a community has a large share of the available cover he may actually find more hunters on his farm after joining a cooperative to reduce trespass than before, and the only relief is to bar hunters getting permits at other farms. In some instances it has been suggested that such a farm be made a refuge; however the farmer may want to hunt there himself. Another reason for some of the cooperatives limiting the hunter to one farm is the feuds that frequently exist in rural areas. One owner may refuse to allow anyone on his land whom his neighbor has admitted. In view of these difficulties, the 1940 program has been modified to include a regulation requiring farm committees receiving departmental assistance to allow hunting on an area larger than a single farm.

As to special rules, fourteen cooperatives have a regulation prohibiting Sunday hunting. Four organizations restrict the numbers of dogs to two per party while two others forbid the use of any dog. One community bans raccoon hunting and another the shooting of partridges. Two cooperatives have a regulation to the effect that no hunter shall be allowed on the club area more than twice per week.

Analysis of the farm game management program would be incomplete without some reference to its expense. The entire cost of the work to the State Department of Conservation in 1939, including material, printing, travel, salaries, and delivery of signs was approximately $5,000 or 1 cent per acre involved.

The great majority of hunters who understand the objectives of the game management cooperatives approve of part of their license money being spent to assist in maintaining them. There have, however, been objections. A common one has been that we are furnishing farmers with "No Hunting" signs. This has been the result of superficial observation of signs with the Department of Conservation's name on them that read "No hunting without permission." Farmers have reported that parties of hunters would drive down the road, slow up to read the sign, and then go on. Farm members in some of these organizations have said that no one stopped to ask for a hunting permit. Another frequent criticism comes from the hunter who has made it a practice to hunt in a certain area for several years. The hunting season opens and he finds that his favorite resort is posted

with signs furnished by the Department. Perhaps he stops at the farmer's house only to learn that all the tickets have been given out. The same thing may happen at several other farms in the community and he comes away bitter against the farmers and the Department for preventing him from hunting on the area as usual. He fails to realize that while he has enjoyed himself during previous years on the various farms in the community, the farmers have not been so completely satisfied or they would not have joined in a controlled hunting movement. Many hunters do not yet realize that the farmer is in control both as to the future of game and as to the availability of places to hunt.

Another complaint is that the State Department of Conservation is furthering paid hunting in Michigan through cooperating with the game management organizations. While a few members in one or two cooperative clubs out of the total number in operation have charged for hunting permits, this has been exceptional. Furthermore no Williamston Plan game management cooperative that the Department of Conservation or the Extension Division of Michigan State College (which is assisting in this work) helped organize has yet turned into a paid shooting organization. Some farm communities where paid hunting might be a success have specifically agreed to make no charge in order to get signs bearing the Department's name. In this way fee charging has actually been retarded in some communities. If farmers wish to make a charge for hunting on their land no outside individual or agency will be able to prevent it. In the locality where charging is the most prevalent, namely, Sanilac County, the Department of Conservation is not assisting any cooperative nor has it aided the organization of one. It should be remembered that these game cooperatives were in operation eight years before the Department started to assist farm communities with the work. In a number of instances hunters have encouraged farmers to charge a fee for the hunting privilege.

Again hunters point out that farmers in the cooperatives reserve the tickets for their friends and relatives. This is no doubt true, but what can be done about it? The practice is common among farmers, regardless of whether they are members of an organization or not. It is only human nature to give friends and relatives the first chance. The hunter, therefore, should strive to become a friend of the farmer. He should not wait until the opening day to make arrangements for a place to hunt; that may be too late. In any event, the Department of Conservation cannot tell a farmer who is to hunt on his land. That is his privilege and his alone.

As previously noted, the chief purpose for which most of these organizations were formed was to bring about an orderly harvest, very little being done to produce more game. On that account some may question the value of the cooperatives—but the fact is that the most pressing problems in connection with small farm game in Michigan, were associated with the harvest, hence they were given first attention. Orderly harvesting is certainly a requisite of management. Game is a product of the land and farmers are not inclined to attempt additional production of this when from their point of view greater

difficulties are connected with its harvesting.

An offsetting factor is that when meetings of the cooperative groups are held, many "notions" and "suspicions" harbored by the members are discussed and the Department can throw light upon them and tend to liberalize the farmer's point of view.

Other advantages may be briefly mentioned. One is that as most game animals are to a degree mobile, community rather than individual management must be undertaken, if any great amount of good is to be accomplished. Eight of the cooperatives last year set up refuge areas and winter feeding is a practice common to all of the organizations. Members of these groups claim that game law violations have definitely decreased under the cooperative arrangements.

One difficult problem is to prevent the cooperatives from becoming completely inactive after the close of the hunting season. While a few organizations continue to have meetings during the winter and spring, most of them do not get together until approach of the next hunting period.

In appraising the long time value of the program, we should consider the following points:

1. How large a mortality of cooperatives can be borne and the program still be successful?

2. Are these organizations only a passing phase in the management of small game hunting?

3. Even though a cooperative fails after a few years, is there a beneficial imprint left on landowners or is all that was gained lost?

4. Will the failures add to the number of irresponsible city hunters who are to some degree restrained by an organization?

5. How much can justifiably be spent on the program, mortality causes being beyond control?

6. Is the rate of mortality high enough to warrant much consideration?

One thing is apparent—in an effort to improve farmer-sportsmen relationships these cooperative game management organizations should be only one of numerous conservation activities that should be carried on simultaneously. Controlled hunting cooperatives in reality are treating the effects—not the cause of unsatisfactory hunting conditions.

## SUMMARY

Farm game management cooperatives have been in operation in Michigan for ten years. In 1936 the Department of Conservation decided to assist farm communities with this work. The cooperative organizations increased from one in 1936 to 110 in 1939. They covered about 500,000 acres, and the cost of cooperation to the State Department of Conservation was approximately 1 cent per acre. From the farmer's point of view the primary reason for the formation of these cooperatives was to control hunting trespass, very little attention being given to increased production of game animals. Proximity to urban areas increases difficulty in controlling the game harvest due to the large number of hunters and the tendency toward occupation of small acreages by factory workers.

A degree of mortality occurs among the game cooperatives due principally to situations arising among the mem-

bers themselves. For the most part, the mortality factors are those common to all farm organizations and cannot be controlled by an outside interest. Because of the democratic nature of these cooperative units many different types of rules and regulations are adopted. The majority of the projects allow the hunter access to the entire organized area, although a few limit him to an individual farm. Other regulations restrict Sunday hunting, the taking of certain game species, and the number of dogs used. Under regulations effective in 1940, a farm community in order to secure posting material and tickets, and other cooperation from the State Department of Conservation must allow hunting on an area larger than a single farm.

Game management cooperatives not only reduce trespass difficulty but assist with educational work among farm people, aid with game management activities, and stimulate social events among the rural groups.

The participation of the State Department of Conservation and of the Extension Division of Michigan State College in this work is not increasing paid hunting and has a tendency to keep areas open to well-behaved hunters, while at the same time satisfying the landowners. The cooperative game management organizations are only one of a number of activities that should be carried on simultaneously to improve farmer-sportsman relationships.

Russell G. Hill
Farm Game Extension, Michigan State College
East Lansing, Michigan

# WILDLIFE FOOD PLANTS IN NEW ENGLAND

*Edwin A. Mason*

New England once was dotted with thriving farms and had an equally thriving wildlife population. A sectional self-sustaining agricultural economy was based on a wide diversity of crops. The resultant proportionately extensive areas of woods edges, brushy fence rows, crop residues, and weeds, made the wildlife population larger than that found when the country was first settled. Phillips (1) excellently presents this historical past in his paper discussing "Man's Influence on Ruffed Grouse Populations."

The decline of this phase of New England agriculture began with the opening up of the West. The acreage of arable land has since dwindled to a mere fraction. Stone walls in deep forest are monuments to the agriculture that was, indicating clearly the extent of forest expansion at the expense of agricultural lands.

A factor now operating to reduce the supply of weed seeds available as winter food for wildlife is the corn borer regulations enforced by the U. S. Department of Agriculture. These specify that all corn stubble be plowed under by December 1 each year. Even though most of the corn grown in this section is for silage, and so is grown in heavier stands than when raised for grain, it has some of the weeds usually found with this crop. Due, however, to the requirement of fall plowing they are lost for wildlife food, excepting tips not buried by the furrow.

Thus it is that while we have a plethora of cover, we have on the other hand, for grain-eating species especially, an insufficient supply of those wildlife foods that are a by-product of agriculture.

The conditions just mentioned as being general in New England, came to special attention at the Wharton Bird Banding Station at Groton, Massachusetts in 1935. We had an area of 80 acres roughly divided into 40 acres of apple orchard, 15 acres of grassland, and 25 acres of fresh water marsh, the marsh in places carrying a growth of woody plants. Some years previously dairying had been carried on, and parts of the grassland had been rotated with corn. When this was discontinued, a reduction in the number of songbirds attracted to the area was noticed. The pheasant population also seemed to have dwindled.

To improve conditions we resorted to the food strip, and decided that the Williamston mixture, devised by the University of Michigan (2), seemed to offer a possible solution to our problem of providing food for pheasants and song birds. It was decided to make two plantings. One of the areas selected was a narrow strip of about ¼ acre along the edge of the fresh water marsh, an area where black muck soil gradually changed to a clayey loam as the land gently rose away from the marsh. Growing on the border and in patches throughout the marsh, mixed with the tall herbaceous growth, were red osier, dogwood, aronia, pussy willow, and wild cherry bushes. These were interspersed with occasional small white

birch, poplar, maple, and elm trees. Many of the plants in this growth provided food, but their chief contribution was excellent cover. The other area, an abandoned cow yard of about ¼ acre, had a rich heavy loam soil, but was practically surrounded by an apple orchard. It soon became evident that the cover here was inadequate for optimum results, but planting was continued because no other site was available.

These two areas have been in continuous use ever since as wildlife food strips, the one on the edge of the marsh having been enlarged by widening in 1939, and now comprising about ½ acre. As managed the orchard has on several occasions supplemented the food strips by an after fallow, buckwheat planting, or a crop of weeds.

In the spring of 1935 the first varied collection of seeds for a food strip was mixed and sown. Several of these plants were new to this part of the country, so no information regarding their possible performance could be had.

For three years we blamed the weather for failure of the sorghums to mature and for the spotty performance of the corn, as our hopes failed of full realization at the season of harvest. But we were also asking ourselves if various cultural practices had not contributed to the lack of complete success of the food strips. Eventually it became obvious that some of the plants in the mixture were not suited to our conditions.

Experiments proved that sowing in drills, followed by some cultivation, was preferable to broadcasting. Unfortunately drilling in all the seed was not practical for the reason that drills suitable for this work are seldom a regular piece of farm equipment in this section, and further that only hand power was available for cultivation of the growing crop.

Another factor of great importance in this matter of broadcast sowing versus row planting, is that the need for food strips is greatest where the least tillage is carried on. Landowners and individuals or groups holding hunting rights, the people who could make the greatest contributions to wildlife by planting food strips, would in most instances have to hire help just as we do to get strips sown.

As a rule this would require hauling the necessary equipment a considerable distance to the proposed site. To keep costs down under these conditions it is essential that the whole operation of plowing, disking, smoothing, sowing, and covering, all be accomplished at one trip. While this is far from being the most desirable cultural practice, the conditions that impose it should be borne in mind while planning for wildlife food strips in New England.

Experience has taught that too much seed per acre is worse than too little. We have also learned that it is practically impossible to sow broadcast a mixture containing a large proportion of small seeds without getting it on too thickly unless an adulterant is added. Twenty pounds per acre is sufficient if losses from exposed seeds being eaten can be kept at a minimum. Some losses are unavoidable, however, when broadcast sowings are made, and under some conditions twenty-five pounds per acre would not be too high a rate. Adding sawdust in volume equal to that of the seeds will make the mixture easier to sow, and will at the same time give a

more even and more widely spaced stand.

Much of the best pheasant cover in this part of the country is around fresh water marshes. Often the best location for a food strip is along the edge of such a marsh. In most cases the soil is of the black muck type, and not so suitable to seed-bearing crop plants as are the upland soils. Adaptability of soil is another factor needing careful study. Perhaps ultimately it will be found possible to recommend to landowners and sportsmen seed mixtures satisfactory for each distinct soil type.

Our experience with the plants composing the Williamston mixture, and a few added species, can be briefly summarized as follows:

*Sorghum.* Feterita, Milo Wheatland, Milo Doura Branching, and Early Amber have been used. There has been no indication that any of them can be relied upon to ripen seed or to stand up through the winter.

*Corn.* Many varieties of sweet corn have been tried, as well as two of popcorn. Grown in conjunction with the other components of the mixture, especially when sown broadcast, only rare individual plants attain a robust growth and ripen seed. Experiments in 1938 with row plantings of Japanese Hull-less popcorn, and South American Mushroom popcorn, proved that this type of corn had much to offer as a wildlife winter food plant. Both varieties matured seed which kept well in shocks. As the ears were made available by turning the sheaves, they were cleaned up by pheasants, with incidental usage by blue jays and gray squirrels. It is believed the formation of the grain on the ear of South American Mushroom, being more like that of field corn than is that of Japanese Hull-less, makes it much more easily shelled by wildlife, and so preferable.

*Buckwheat.* As a producer of palatable grain, buckwheat is without a peer. On the other hand its straw is weaker than most. Sown with the mixture, a fair percentage usually lodges on other plants, thus making available some of the seed produced. Most of the seed, however, shatters long before spring. Sown by itself, it is not available when most needed, although pheasants are able to get at it by scratching through light falls of snow. A between-the-row planting in an apple orchard in 1938 did yeoman service through a hard winter, birds feeding on the area until after the spring thaw. This orchard is on a slope conducive to snow melting, and patches of ground in it became bare regularly throughout the winter after brief thaws, making the buckwheat seed available. This area was frequented throughout the winter to a greater degree than were the regular food strips. In the spring of 1939 a mixture of buckwheat and sunflower in about a 3 to 1 ratio by weight was sown broadcast. This experiment was partly to find a crop that could be sown in rotation with the food patch mixture—one that would smother out part of the excessive growth of weeds accumulated during use of the mixture on the area. It was hoped that the sunflower stems would provide support for, and hold up through the winter, the weak-stemmed buckwheat. It would be inadvisable to draw final conclusions at this time, but the indications are that this mixture is worthy of further experimentation.

*Soy Bean.* Both Manchu and Black

Wilson have been used. Manchu seems more adaptable to the purpose and conditions. Since being sown in thinner stands this bean has done much better. The heaviest setting of seeds pods occurred in the drought year of 1939.

*Sudan Grass.* Although experiments at the University of Wisconsin (3) indicate a low palatability for the seeds of this plant, and further that its ability to stand erect and hold up other plants with weak straws is inferior to that of other species, until something better is available it has value under our conditions in holding up weaker plants, even though the upper part of the stem does usually break, or bend over, soon after the first frost.

*Hemp.* Generally this plant does not do well enough to warrant inclusion in a mixture for our region.

*Flax.* Flax seems able to set seed under any conditions and retains it well. There are indications, however, that its seed rates low in palatability.

*Millet.* The varieties of millet used have been reduced to German, Japanese, and Early Fortune Proso. German and Japanese are reliable seed producers, and both stand up surprisingly well considering their slender straw, retaining seed usually until spring. Songbirds consume most of the seed prior to winter. A wet spring in 1938 proved that Japanese millet can withstand soggy soil conditions that were largely fatal to German millet; it seems to have value for low-lying lands. Proso matures seed regularly, but it ripens early enough to bear the brunt of feeding by small birds prior to migration. If uneaten it shatters long before winter.

*Cowpea.* Three years experience with this plant showed rather conclusively that it is not suited to our conditions.

*Sunflower.* The dwarf branching varieties are preferable to the Giant Russian. The giant type, however, even though it breaks, or bends over, does help to hold up other plants. The seeds of both-varieties, apparently regardless of the amount produced, are exhausted before winter by song birds.

*Artichoke.* Leopold (4) suggested that Jerusalen artichokes (*Helianthus tuberosus*) might prove a source of winter food for pheasants and other wildlife in this country as they do in Germany. In November 1936 tubers from an escaped patch of these plants were exposed, but were quickly frozen. In 1937 a small planting was made in rows and cultivated several times. Tubers from this planting were exposed in October, but rapidly disintegrated under the repeated freezes and thaws to which they were subjected. Some tubers were partly eaten by pheasants, but this crop seems to offer little here as a wildlife winter food. A more thorough investigation than we could give might show that artichoke tubers would be a valuable spring food. Tubers unearthed as soon as the ground thawed in spring would provide a succulent vegetable at a time when such food is scarce. Research might prove such a food to be of great value to birds about to enter the period of sexual activity and reproduction.

*Common Vetch.* Knowing the legumes as a group were valuable wildlife food plants, the sight of a pole bean running up a giant sunflower was responsible for consideration being given to finding a legume that would grow in this section, climb a sunflower, and the same year it was sown ripen seed that would

have value as a wildlife food. The advice of W. L. McAtee, Technical Advisor, U. S. Biological Survey, eventually was sought. He suggested that vetches would probably serve the purpose, mentioning specifically the hairy vetch, *Vicia villosa*, and common vetch, *Vicia sativa*.

In the spring of 1938 a sowing was made of common vetch and giant sunflower. Although the rate of sowing was such that the sunflowers were too close to make maximum growth, and although a rank growth of weeds came up in the broadcast sowing, the vetch plants did make satisfactory growth. So many opportunities for climbing were presented to the vetches by weeds, that they became attached to only a small percentage of the sunflower stems. However, a number did, and set seeds, so that the experiment of growing these two plants in combination was deemed worthy of further trial.

In 1939 a broadcast sowing of 3 lbs. of Russian sunflower and 1 lb. common vetch seeds, to which was added an equal part by bulk of sawdust, was made on an area of about 1/10 acre. Observations made soon after the plants came up indicated that the rate of sowing was probably about right. Unfortunately both species of plants were eaten off by rabbits and probably also by woodchucks, all of the sunflowers being destroyed. The vetch plants stooled out after being grazed off, but subsequent grazings carried into early summer, prevented them from keeping pace with the weed growth and maturing.

Graham (5) points out that the vetches are used as food by 22 birds and 4 mammals. The pheasant is known to feed upon 17 species of legumes. Thus there is excellent authority for continued experiments with them. Here again the cultural value of row planting would unquestionably aid both the vetch and the sunflower plants in attaining maximum growth, as well as insuring that they became established in close proximity to each other. But, as previously pointed out, there are practical reasons for continued experiments with broadcast sowings. Protection by fencing, or by some other method, is obviously indicated where rabbits are numerous.

Merely to call attention to them as possible sources of food for pheasants, worthy of more complete investigation, mention is made of two tree species growing as ornamentals on the Wharton Station. Neither are commonly found in this region, and so perhaps for that reason are usually not considered as possible sources of wildlife food. They are catalpa, *Catalpa catalpa*, and yellow-wood, *Cladrastris lutea*. Pheasants have been observed at close range during the spring eating seeds from the pods of catalpa. Only the inferential evidence of feeding beneath it can be offered in the case of the yellow-wood, but attention is called to the fact that this tree belongs to the family Leguminosae, and produces a small seed similar in appearance to vetch seed.

It is unfortunate that checking on utilization of the food strip plants other than by the observational method was not possible because the area is a sanctuary. There seems little doubt, however, that the plantings, supplemented by hopper-fed cracked corn during periods of heavy snow, have at least attracted into the area higher populations of pheasants and small birds than

generally exist in similar surrounding areas, demonstrating that the wildlife food strip has value in New England.

## SUMMARY

Because of the low proportion of arable land on the Wharton Bird Banding Station at Groton, Massachusetts, a condition prevailing in much of New England, it is necessary to provide a source of winter food for seed-eating species of wildlife if a maximum population is desired. Experiments with the Williamston food strip mixture, and variations of it, have shown that it is impossible reliably to mature the sorghums, cowpeas, field corns, and hemp, when these are sown broadcast in mixtures. On the other hand, buckwheat, millet, flax, soy bean, Sudan grass, sunflower, and common vetch, apparently have value for food patches. It has been found that thinner stands of these plants can be attained by adulterating the seed mixtures with sawdust prior to sowing. The popcorn strains of *Zea mays* should receive more attention as a potentially valuable wildlife food plant. The tubers of Jerusalem artichoke freeze too easily to be desirable as a winter food, but further research may prove them to have value as an early spring food. Experimentation with seed-producing plants should be continued, in search of a mixture that will be able to stand up through the winter, preferably one than can be sown broadcast.

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Edwin A. Mason
Wharton Bird Banding Station
Groton, Massachusetts

# A STUDY OF DEER POPULATIONS BY USE OF PELLET-GROUP COUNTS[1]

*Logan J. Bennett, P. F. English, and Randal McCain*

In an effort to devise a simple, practicable, and inexpensive method of censusing white-tailed deer (*Odocoileus v. virginianus* and *O. v. borealis*), the writers have been investigating the possibility of using pellet-group frequencies as an index to deer populations. From the time man first began to hunt deer, he probably used pellet groups—along with other signs—as an indication of where he would be most successful in the hunt. Technical workers have used the frequencies of pellets as a key to population estimates of other animals. Vorhies and Taylor (1933) used pellet counts of jack rabbits in determining the relative abundance of those animals. Taylor, Vorhies, and Lister (1935) correlated jack rabbit and cottontail pellet counts with the relative abundance of those species. Hendrickson (1936) used pellet counts to obtain information on the local range and on cover and food requirements of cottontails in Iowa.

As a trial procedure the writers established during the spring of 1938 several 1/10-acre quadrats, selected at random in the scrub oak-pitch pine (*Quercus prinoides*, *Q. ilicifolia*, and *Pinus rigida*) forest type in Centre County, Pennsylvania, the corners of the quadrats being marked with 1- by 1- by 24-inch stakes. The area in general is known as the "Barrens." These quadrats were established and cleared of all pellets in May and June 1938. Thereafter they were observed monthly throughout the summer. At each inspection the deer-pellet groups were counted and removed. Two strips selected at random were also set up in a chestnut oak (*Quercus montana*) forest type in the Seven Mountains, Centre and Huntingdon Counties, Pennsylvania. These were 11 feet wide and 1,000 and 2,000 feet long, respectively, and were placed at right angles to the contour of the land. The lines were marked with white paint on the tree trunks at about 30-yard intervals. The marked trees were the center lines.

Pellet-group counts made during the summer of 1938 led the writers to investigate further the possibilities for using such counts to estimate relative deer populations in the respective forest types.

A number of limitations and difficulties were apparent by October 1. During the latter part of September leaves began to fall, and it was then impossible to count pellet groups accurately. The spring counts could be started during April, as by that time the heavy snows of the previous winter had melted and there was little likelihood of further snowfall. Thus the factors of falling leaves and snowfall caused the writers to concentrate their preliminary efforts on spring and summer pellet-group counts.

The number of 1/10-acre quadrats selected in the Barrens in the scrub oak-

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pitch pine forest type ranged from 8 to 25 during the period June to September 1938. The plots were cleared of pellets in May and June, and complete monthly counts of the pellet groups were then made until the end of September. The scrub oak-pitch pine lands have been burned repeatedly during the past 30 years. The vegetation is low and affords excellent deer food and cover. Table 1 shows the monthly summer counts of deer-pellet groups in the Barrens, Centre County, during 1938.

From daily observations made during September by the writers and by members of the Department of Forestry of The Pennsylvania State College, it was estimated that the deer population in that area was about 1 deer to 15 acres. After an antlerless-deer hunting season in November–December 1938, however, counts in the area made from a low-flying aeroplane over snow-covered ground revealed a population of 1 deer to 18 acres.

As may be seen in the table, the pellet-group counts in the scrub oak-pitch pine area disclosed a monthly average of 33.4 pellet groups to the acre. Thus the pellet-group counts indicated that about 1 deer to 15 acres was depositing pellet groups at the rate of 33.4 groups an acre a month.

The two strips set up in the chestnut oak type of the Seven Mountains were cleared of pellets in May 1938, and monthly pellet-group counts were made thereafter until the end of September. This chestnut oak type belonged to the 35- to 100-year age class and had been overbrowsed several years prior to the time of this study. The closing of the canopy had also reduced the carrying capacity of the area for deer, and the deer population in such sections was much smaller than in the scrub oak-pitch pine. In Table 1 are given the results of the monthly counts on the two chestnut oak strips.

TABLE 1

PELLET-GROUP COUNTS MADE IN SCRUB OAK-PITCH PINE QUADRATS, BARRENS, CENTRE COUNTY, SUMMER, 1938

| *Month* | *Quadrats* | *Acres* | *Pellet groups* | *Groups to the acre* |
|---|---|---|---|---|
| June | 8 | .8 | 25 | 31.2 |
| July | 24 | 2.4 | 96 | 40.0 |
| August | 25 | 2.5 | 79 | 31.6 |
| September | 24 | 2.4 | 74 | 30.8 |
| Average per month per acre | | | | 33.4 |

Observations made on these strips by field-workers of the College and by the writers indicated a deer population of 1 deer to 50 acres in September 1938. From counts made by the writers over the snow-covered terrain from a low-flying aeroplane after the antlerless-deer hunting season, it was estimated that the deer then numbered 1 deer to 72 acres.

The pellet-group counts, as shown in Table 2, indicated that about 1 deer to 50 acres was depositing pellet groups at the rate of 8.2 groups an acre a month.

TABLE 2

PELLET-GROUP COUNTS MADE IN CHESTNUT OAK AREAS, SEVEN MOUNTAINS, CENTRE AND HUNTINGDON COUNTIES, SUMMER, 1938

| *Month* | *Strips* | *Acres* | *Pellet groups* | *Groups to the acre* |
|---|---|---|---|---|
| June | 2 | .77 | 4 | 5.2 |
| July | 2 | .77 | 4 | 5.2 |
| August | 2 | .77 | 9 | 12.0 |
| September | 2 | .77 | 8 | 10.4 |
| Average per month per acre | | | | 8.2 |

The apparent relationship between pellet-group densities and distribution led the writers to increase the number of sample areas in 1939. Accordingly, the quadrats in the scrub oak-pitch pine were reestablished in 1939; and, in

addition, a strip 11 feet wide and half a mile long was set up in a mixed-oak (*Quercus borealis* var. *maxima*, *Q. coccina*, *Q. alba*, *Q. velutina*, and *Q. montana*) forest type of the 35- to 40-year age class, adjacent to the scrub oak-pitch pine area. These two associations make up the major forest types of the Barrens. The deer utilize the mixed-oak environment in conjunction with the scrub oak-pitch pine.

TABLE 3
PELLET-GROUP COUNTS MADE IN SCRUB OAK-PITCH PINE QUADRATS, BARRENS, CENTRE COUNTY, SUMMER, 1939

| *Month* | *Quadrats* | *Acres* | *Pellet groups* | *Groups to the acre* |
|---|---|---|---|---|
| June | 17 | 1.7 | 85 | 50 |
| July | 17 | 1.7 | 40 | 23 |
| August | 17 | 1.7 | 43 | 25 |
| September | 17 | 1.7 | 28 | 16 |
| Average per month per acre | | | | 28.5 |

Tables 3 and 4 show the monthly summer pellet-group counts made in the scrub oak-pitch pine and mixed-oak quadrats in 1939. The average monthly pellet-group count in these two forest types combined was 21.2 pellet groups an acre. These sample plots were situated in an area of about 3,000 acres, one that is representative of about 20,000 acres in Centre County.

TABLE 4
PELLET-GROUP COUNTS MADE IN MIXED-OAK QUADRATS, BARRENS, CENTRE COUNTY, SUMMER, 1939

| *Month* | *Strip* | *Acres* | *Pellet groups* | *Groups to the acre* |
|---|---|---|---|---|
| June | 1 | .66 | 5 | 7.5 |
| July | 1 | .66 | 12 | 18.0 |
| August | 1 | .66 | 14 | 21.0 |
| September | 1 | .66 | 6 | 9.0 |
| Average per month per acre | | | | 13.9 |

Seven additional strips were established during 1939 in the chestnut oak forests in the Seven Mountains, bringing the total number of strips to nine. All were selected at random in an area of about 10,000 acres representative of the mountain region of central Pennsylvania. Table 5 shows the monthly pellet-group counts on these chestnut oak strips during the summer of 1939. The average pellet-group count was 6.48 groups an acre a month. The deer population on such lands in September was probably 1 deer to 60 acres.

By correlating the deer populations in the the Barrens and in the Seven Mountains with the deer pellet-groups counts during the summer months in the respective forest types, it was found that a definite relationship did exist between pellet-group frequencies and the deer populations. In the Barrens 21.2 pellet groups a month were recorded, with 1 deer to about 15 acres; in the Seven Mountains 6.48 pellet groups an acre a month were counted, with a deer population of 1 deer to about 60 acres.

TABLE 5
PELLET-GROUP COUNTS MADE IN CHESTNUT OAK AREAS, SEVEN MOUNTAINS, CENTRE AND HUNTINGDON COUNTIES, SUMMER, 1939

| *Month* | *Strips* | *Acres* | *Pellet groups* | *Groups to the acre* |
|---|---|---|---|---|
| May | 4 | 2.07 | 18 | 8.6 |
| June | 10 | 4.41 | 29 | 6.5 |
| July | 10 | 4.41 | 33 | 7.4 |
| August | 10 | 4.41 | 16 | 3.6 |
| September | 10 | 4.41 | 28 | 6.3 |
| Average per month per acre | | | | 6.48 |

A series of strips and quadrats established on three areas on the Allegheny National Forest in June and December 1938 and observed until September 1939, presented some interesting data for comparison with those obtained during the same period on areas in the Seven Mountains and the Barrens (Table 6). The deer census figures in Table

TABLE 6
DEER PELLET-GROUP COUNTS AND DEER POPULATIONS, JUNE 1938–SEPTEMBER 1939

| Locality | Forest type | Strips and quadrats (Acres) | Pellet groups per acre | Acres per deer | |
|---|---|---|---|---|---|
| | | | | 1937 | 1938 |
| Seven Mountains (Huntingdon and Centre Counties) | 40- to 100-year-old chestnut oak | 44.8 | 11.7 | 60 | 72[1] |
| Middle Hickory (Allegheny National Forest) | dense pole stand | 3.43 | 18.7 | 46 | 69[2] |
| Cole Run[3] (Allegheny National Forest) | three timber types | 5.28 | 24.9 | — | 15[2] |
| Barrens (Centre County) | scrub oak-pitch pine | 38.78 | 26.4 | 14 | 18[1] |
| Dunham Siding (Allegheny National Forest) | slash | 1.3 | 54.0 | 6 | 14[2] |

[1] Daily observations and airplane counts.
[2] Drive figures (McCain, 1939).
[3] Pellet-group counts in this area were made from December 1938 to August 1939.

6 were obtained during December 1937 and December 1938, after the annual hunting season. The summer figures in 1938 and 1939 were higher than the December figures because of the annual fawn crops. The ratios between the number of pellet groups and the deer populations on the Allegheny National Forest, the Seven Mountains, and the Barrens appear to be indicative of the relative abundance of deer in all areas under observation as tested by figures obtained by other census methods.

The data indicate that for general forestry and wildlife-management purposes, pellet-group counts have excellent possibilities of providing an economical census method.

Although the primary purpose of this investigation was to try to develop a census method, other interesting and valuable indicators have become apparent. The pellet-group counts reveal deer movement and utilization by the deer of the different forest types and subtypes. Deer deposit a great proportion of their pellet groups near where they feed, so that the distribution of the pellet groups becomes a useful key to forage preferences.

The writers recorded the overwinter pellet groups on all quadrats and strips when they were cleared the first time in the spring of 1939. The counts represented pellet groups from the previous December (after complete leaf-fall) until May, a period of 5 months. The overwinter, 1938–39, monthly average in the Seven Mountains was 17 groups an acre; while 41 groups a month to an acre were recorded from the Barrens area. The winter counts were higher each month in both areas than the monthly counts made during the summer. This can be partly explained by the fact that deer in both areas go to old fields for more of their food from May until November than during the other months of the year. Grasses, forbs, and low-growing shrubs in the old fields become available in May and are utilized until frost and snow make them unavailable in November.

The year-round pellet-groups counts in the Barrens, including those made in old fields, were segregated according to

seasons to determine if pellet-group distribution indicated seasonal variation in forest-type use. The figures (Table 7) appear to present a clear idea of the use by deer of the three dominant cover types in the Barrens environment throughout the year. Observations of deer in that area at all times of the year substantiated the seasonal differences of use in the respective cover types as indicated by the pellet-group distribution.

TABLE 7

PELLET-GROUP COUNTS IN BARRENS AREA, 1938–39

| *Periods* | *Pellet groups per acre* | *Time spent in each type (Per cent)* |
|---|---|---|
| Year-round average (except October and November) | | |
| Scrub oak | 50.2 | 63.3 |
| Mixed oak | 22.9 | 28.8 |
| Grassland (old fields) | 6.2 | 7.8 |
| 1939—Summer use (June, July, August and September) | | |
| Scrub oak | 28.5 | 56.8 |
| Mixed oak | 13.9 | 27.7 |
| Grassland | 7.7 | 15.3 |
| 1939—Winter use (December to May) | | |
| Scrub oak | 58.0 | 66.5 |
| Mixed oak | 24.0 | 27.5 |
| Grassland | 5.1 | 6.0 |

The use of pellet-group counts for census and movement-study purposes has brought out a number of points that must be taken into consideration if this technique is to be used properly. Deer pellets comprise a variety of sizes and shapes. The most common type of pellet is ovoid and is about the size of a large pea. During the spring and summer, defecations are often masslike similar to those of cattle. The pellets may be deposited in close groups, or they may be scattered over several yards. The writers recorded a single pellet as a group if it was clearly distinct from any other group. Often a deer defecated all the way across a strip or quadrat. Such scattering of pellets could always be accounted for easily, and only one group was recorded.

It was found that the texture of the pellets changed in the spring, when the deer began to feed on new shoots. This occurred about the time the shadbush (*Amelanchier canadensis*) bloomed, early in May. Pellets defecated during the winter deteriorated very little before spring. Spring and summer pellets were sometimes attacked by insects and millepedes. By making monthly counts, however, even though these scavengers had rifled a pellet group, there was enough residue to be recognized. Many pellets last at least 13 months. In June 1938 a number of pellets were marked with stakes. At the end of 12 months they were still evident. At the end of 13 months they would not have been noted if the observer had not known they were there. Pellets may last even longer in the forest under a heavy matting of leaves. It was noticed that after wet weather old pellets—of unknown age, but at least 8 months old—swelled up and heaved from under the leaf-mat of the previous fall. These pellets were easily identified as being old and were not counted.

Pellets can most easily be detected on cloudy days, or in the morning before the sun gets bright. Glaring sunlight increases the chance of missing pellet groups.

## SUMMARY

1. Quadrats of 1/10 acre and strips 11 feet wide with varying lengths were established at random in various forest

types and were cleared periodically of deer-pellet groups.

2. Pellet-group counts made during the summer of 1938 in scrub oak-pitch pine, Barrens, Centre County, Pennsylvania, indicated that 1 deer to 15 acres was depositing 33.4 pellet groups an acre a month. Summer counts for 1939 in the same area, with approximately the same deer population, averaged 28.5 pellet groups an acre a month.

3. Pellet-group counts made in 35- to 100-year age class chestnut oak, Seven Mountains, Centre and Huntingdon Counties, during the summer of 1938 revealed that 8.2 pellet groups an acre a month were deposited by 1 deer to about 50 acres. Counts made during the summer of 1939 in the same area indicated that 6.48 pellet groups an acre a month were deposited by 1 deer to about 60 acres.

4. Year-round pellet-group counts made over a 16-month period on the Allegheny National Forest, Pennsylvania, indicated the following: 18.7 pellet groups an acre a month were deposited by a deer population of 1 deer to 46 to 69 acres; 24.9 pellet groups an acre a month were deposited by 1 deer to 15 acres; and 54 pellet groups an acre a month were deposited by 1 deer to 6 to 14 acres. Over the same period, counts made in the Seven Mountains disclosed that 11.7 pellet groups an acre a month were deposited by 1 deer to 60 to 72 acres; counts made in the Barrens indicated that 26.4 pellet groups an acre a month were deposited by 1 deer to 14 to 18 acres.

5. A study of pellet-group distribution in all forest types in the Barrens, Centre County, indicated that the determination of seasonal use of the respective forest types by deer was feasible by the use of pellet-group counts.

6. The preliminary work reported on in this paper suggests that pellet-group counts can be used for determining approximate deer populations, deer movement, and the utilization of forest types by deer.

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Logan J. Bennett
U. S. Bureau of Biological Survey
1-A Horticulture Building
State College, Pennsylvania

P. F. English
Department of Zoology and Entomology
The Pennsylvania State College
State College, Pennsylvania

Randal McCain
U. S. Forest Service
Warren, Pennsylvania

# UTILIZATION OF OAKS BY BIRDS AND MAMMALS

*William R. Van Dersal*

The most important and the most abundant and widely distributed genus of hardwood trees in the north temperate zone is that of the oaks. Within the United States a variety of species of oaks are important dominants in the various associations of the eastern hardwood forest. Extensive areas of oak savannah locally often known as "shinnery" extend in two great belts through Central Texas and Oklahoma. Oaks appear prominently also in the forests of the Lake States and of New England as well as in the southern pinelands, swamps, and hardwood bottoms. For the eastern half of the United States perhaps no other genus of broadleaf trees is as well represented both in number of species and individuals, as are the oaks.

In the West oaks are confined largely to the southern areas, where they form a diversified complex that has long been troublesome to the classifier. They grow in great abundance in the southern Rocky Mountain region, as well as in California where a considerable proportion of the chaparral consists of oak scrub. As recently shown (Graham, 1937), however, the genus is almost entirely unrepresented in the 12,000 square miles of the Uinta Basin of northeastern Utah and northwestern Colorado. From this great valley north along the mountains there appear to be no oaks at all (Felt & Rankin, 1932). Wherever they occur in the West, oaks are more commonly shrubs or small, rather than large, trees although some of the California species are an exception.

Representatives of this important genus figure largely in the plans of foresters as their timber is of great commercial value. Volumes have been written concerning the silviculture and utilization of oaks. These trees produce many valuable materials including fuel, charcoal, and tannin, and their acorns have provided substantial and sustaining food for aborigines as well as civilized man, and for his livestock. Horticulturally they have contributed much to the beautification of city streets, parks, and gardens. In the Old World they have been worshipped and in the New World they are used to mark many historic sites.

Such values have long been common knowledge, but another value, less generally recognized, is the very considerable part played by the oaks in furnishing a substantial and sustaining food for wildlife. It is to be expected that animals would make much use of plants so numerous in individuals and so widespread in their distribution. In fact, few treatises on birds or mammals fail to mention acorns as the food of some animal or another, if any foods at all are listed. The records are widely scattered, but in accumulating data with respect to the utilization of woody plants by wildlife for another purpose (Van Dersal, 1938b) those for oaks were found to surpass the records for most other genera of woody plants.

Some part or another of an oak plant is now known to be eaten by 186 different kinds of birds and mammals (literature and Biological Survey files). This

number exceeds that for any other genus of woody plants with the possible exception of *Rubus*. Every part of the plant is utilized. Acorns are eaten by a very considerable number of birds and mammals and are frequently classed as "favorite foods." Sprouted acorns are taken by the bob-white, squirrels, deer, and mice; oak leaves are an important browse of deer; the cambium is used by sapsuckers; the bark is eaten by porcupines, the twigs by beavers, the staminate aments by prairie chickens, and even the galls, besides furnishing food for the contained insect larvae, are eaten by several kinds of birds. This account, of course, leaves out of consideration purposely the great army of insects that feed in various ways on all parts of the oaks. The geographic distribution of a number of animals has been stated to coincide with or be dependent upon the range of oaks; such include the raccoon (Bailey '26), band-tailed pigeon (Bendire '92), California woodpecker (Ritter '38), and others. The great dependence placed upon the acorn crop by turkeys, squirrels, chipmunks, and even bears, is common knowledge.

## UTILIZATION OF ACORNS

Acorns are eaten by such common animals as grackles, starlings, jays, crows, woodpeckers, foxes, and deer, as well as by the much rarer thick-billed parrot and peccary of the extreme Southwest, the lesser prairie chicken, ivory-billed woodpecker, Sonora white-tailed deer, moose, and the Abert squirrel. According to the existing records they are used by such small birds as the titmouse, chickadee, and nuthatch, as well as by the larger cranes, white-fronted geese, wild turkeys, and sooty grouse.

Waterfowl, such as the gadwall, golden-eye, wood duck, hooded merganser, mallard, American pintail, black duck, redhead, and greenwinged teal have been known to include acorns in their diet. Ten kinds of jays, 14 kinds of woodpeckers, and many songbirds are on record as eating acorns. The data reveal that 6 of the 7 species of quail of the United States devour acorns, in addition to other upland game birds including the sooty, ruffed, sharp-tailed, and pinnated grouse, doves, and the band-tailed pigeon, ring-necked pheasant, and wild turkey.

The remarkably close association of the California woodpecker with oaks has recently been treated at considerable length by Ritter (1938) in "The California Woodpecker and I." "As a rule," he says, "the species is bound to the oaks of its general area almost as closely as honeybees are bound to flower-producing plants, and for much the same reason: their chief staff of life is the fruit-acorns—of these trees" (p. 16). "The distribution of the species of oaks in this region is coterminal, speaking broadly, with the geographic range of the California woodpecker" (p. 17). The bird patronizes eight species of oaks (as well as *Lithocarpus densiflora*, not treated here), storing the acorns of all of them. Some of the trees employed for storage are figured, and one is estimated to contain 30,000 holes made by these birds to hold acorns.

Handley (in Stoddard, 1932) found acorns or fragments of them in 272 out of 1,659 bob-white stomachs examined in the famous quail study in the Southeast. His tabulations show oak fruits

to compose 6 per cent of the total annual food of the bob-white, and to constitute 48.5 per cent of the meals of the individuals in which they were found. Acorns were identified in stomachs collected in every month but May and September, and in March and April formed 17.4 and 16.3 per cent, respectively, of the food consumed. A quail crop content figured in "The Bob-white Quail" shows one bird to have eaten 11 whole acorns. Stoddard has declared oaks to be a source of staple food for the bob-white in the Southeast, and more reliable than pine mast. Martin (1935) ranked oak acorns as sixth in his list of important quail foods of the Southeast, and Errington and Hamerstrom (1936, p. 381) classed squirrel-opened acorns as a "native food of high winter sustenance value for bob-white." And Errington (1936) has said that in the winter management of wildlife, particularly bob-white in the North Central States, far more emphasis should be placed upon keeping the environment well supplied with foods of substantial nutritive value rather than of succulent "salad types" although the latter may be conspicuously relished. In his list of such staples appear acorns.

TABLE 1
PERCENTAGE OF ACORNS IN SOME ANIMAL DIETS

| *Animal* | *Authority* | *Place* | *Season* | *Total number of stomachs examined* | *Number of animals containing acorns* | *Per cent of total food* |
|---|---|---|---|---|---|---|
| Ruffed grouse | Biol. Surv. (Bi. 1297) | Northeastern United States | Dec. to March | 111 | | 5.0 |
| " " | Gross 1937 | Northeastern United States | Yearlong | 1,055 | 337 | 11.6 |
| " " | Nelson et al. 1938 | Virginia | Fall | 185 | 56 | 10.6 |
| Bob-white | Handley in Stoddard 1932 | Southeastern United States | Yearlong | 1,659 | 272 | 6 |
| " | " " " | " " | March | 41 | | 17.4 |
| " | " " " | " " | April | 15 | | 16.3 |
| " | Gray 1938 | Alabama Black Belt | Winter | 440 | 44 | 2.9 |
| " | Errington 1939 | North Central States | November | 10 | | 6 |
| Prairie chicken | Gross 1930 | Wisconsin | Fall | 17 | 4 | 4.5 |
| Mallard | McAtee 1918 | United States | Yearlong | 1,725 | | 2.3 |
| California woodpecker | Beal 1910 | California | Yearlong except Feb., Apr., May | 75 | | 52.4 |
| " | " " | " | November | 12 | | 93.6 |
| Steller's jay | " " | " | Yearlong | 93 | 38 | 42.5 |
| " " | " " | " | January | | | 99.0 |
| California jay | " " | " | Yearlong | 326 | | 38.2 |
| Raccoon | Hamilton 1936 | New York | Nov.–Jan. | 127 | 16 | 5.9 |

Table 1 shows some percentages of acorns in the diets of various animals. Considering yearly averages, the proportion of acorns is surprisingly high since for long periods they are ordinarily not available in quantity. The percentages for months when acorns were probably plentiful, however, disclose significantly great values.

In a recent paper Lay and Siegler (1937) discuss the manner in which acorn meat is made available to bobwhites in Walker County, Texas, chiefly by blue jays but to some extent also by squirrels and hogs. Their counts showed that 11,400 of the 42,000 acorns produced by a red oak (*Q. rubra*), and over 26,000 of the more than 100,000 acorns produced by a water oak (*Q. nigra*), were made available to quail by these agents. Handley (in Stoddard, 1932) also called attention to blue jay work, although he found that the bobwhite could open acorns unaided. Wetmore (1919) has described the specially modified palate of the common grackle which enables the bird to cut acorn shells in half.

In his study of the lesser prairie chicken, Davison (1936) pointed out that acorns were heavily utilized by the birds in the fall, and that oak flowers were an important food in the spring, especially when the acorn crop of the preceding fall had been poor. Some of the acorns eaten were one-half to three-quarters of an inch in diameter and from a half inch to an inch long. Davison believes that worn down fragments of acorn shell containing the hilum serve in lieu of gravel for food grinding. For the greater prairie chicken, Gross (1930) has shown acorns to compose 4.5 per cent of the fall diet, and Schmidt (1936) mentioned them as a preferred food of the same bird.

In the stomachs and crops of 1,055 ruffed grouse, collected for the most part in October, November, and December in New England, 11.6 per cent of the total food consisted of oak material, chiefly acorns, (Gross, 1937). Thus *Quercus* was the most important single source of food; it also ranked fourth according to frequency of taking.

Acorns have been classed as favorite foods of various other species including the prairie sharp-tailed grouse (Schmidt, 1936), raccoon (Bailey, 1926), Rocky Mountain black-tailed deer (Bailey, 1936), black bear (Bailey, 1926), flying squirrels (Howell, 1918), Mearns's quail (Judd, 1905), Apache squirrel (Mearns, 1907), red-headed woodpecker (Bendire, 1895), red squirrel (Klugh, 1927), white-tailed deer (Stegeman, 1937), California mule deer (Robinson, 1937), and Mexican mule deer (Mearns, 1907).

The possibility that some animals seek acorns especially for the grubs they contain is a suggestion that has been made more freely than it has been confirmed. Wormy acorns are rejected by mule deer in California (Dixon, 1934) and unsound acorns are rarely taken by many rodents according to Korstian (1927). Ritter (1938) also has declared that the California woodpecker eats acorns only for their meat, not for any infesting organisms. The galls of *Q. velutina* are reported by Davis (1924) to be opened by the gray squirrel in New York for the grubs they contain, and pine siskins have been observed to open galls for grubs (Bassett, 1923).

Korstian's classic study (1927) of factors controlling germination and early survival in oaks included an analysis of what happened to the seed crops of a number of oaks after reaching the forest floor. To those not familiar with the premium on acorns in the wild, his results may appear startling. A single 65-foot white oak in North Carolina had a calculated total production of 14,075 acorns, of which 83 per cent was de-

stroyed (i.e. at least partly eaten by animals). For 15 chestnut oaks, 74.8 per cent of the acorn crop was similarly utilized by animals, for 9 black oaks 67 per cent, and for 12 white oaks 72 per cent was destroyed. The animals involved were thought to be largely small rodents, such as mice and squirrels, with turkeys and deer doing some "damage." Korstian concludes from these and many other observations that from 90 to 100 per cent of the acorn supply may be consumed by animals.

Nutritional analyses of acorns seem to explain the widespread preference of animals for these fruits. The fat content of acorns of some species compares favorably with that of corn and wheat (Smith, 1929). The carbohydrates are nearly as great as those of corn, although protein is substantially lower. In his admirable discussion of the potentialities of the oaks, Smith mentions the possibility that in the long run the human race has eaten more of acorns than it has of wheat, and points out that acorns have for centuries been a staple for humans in many parts of the world. In fact, he claims that "the genus of oak trees holds possibility, one might almost say promise, of being one of the greatest of all food and forage producers in the lands of frost."

The utilization of acorns by wildlife has often been considered with some apprehension by the forester. Korstian, for instance, believes that in view of the great amount of damage rodents do to the acorn corp, emphasis must not be placed on their beneficial relations to woodlands. On the other hand, Olmsted's study (1937) in the Connecticut sand plains shows that black oak invades many communities through burial of its acorns by squirrels, and Hofman (1923) concluded that for several western states rodents have played a large constructive part in the success of the natural regeneration of forests, in spite of the fact that these seed eaters are usually considered nuisances by foresters. Klugh (1927, p. 27) summarized the relation of squirrels to forests by saying that "as regards seeds and nuts there is an immense overproduction as compared with the number which fall in situations where they can germinate, and a very much larger number of young trees start than can ever reach maturity, so that there is no evidence to show that squirrels, by their seed and nut eating proclivities, in any way interfere with forest reproduction."

### BROWSE VALUES

The palatability of the leaves of oaks appears to be high for livestock as well as for wild herbivores (Dayton, 1931). Mule deer on the Kaibab and white-tailed deer in the eastern United States depend to a considerable extent on oak browse. For the far West, it may be noted that the California mule deer is recorded as having browsed on every species of oak but one within its range. Several of the oaks are considered to be of outstanding importance for the deer particularly in winter; the scrub oaks are classed by Dixon (1934) as "about the best and most dependable food supply of southern (California) mule deer in winter," and Orr (1937) says that the Columbian black-tailed deer in California apparently find *Quercus chrysolepis* a highly palatable food. Interestingly enough Leopold (1936) rates the oak as number one on a list of the most

palatable browse plants for German deer, and Murie (1934) believes moose relish the browse provided by the red oak (*Q. borealis*).

The statements in the preceding paragraph apply to herbivores in the wild. In feeding experiments with Rocky Mountain mule deer and Arizona white-tailed deer, Nichol (1936) found three oaks (*Q. oblongifolia, Q. emoryi, Q. arizonica*) to be highly palatable at all seasons. So far, however, studies that would relate the observed palatability to food value are lacking.

Nutritional analyses of the leaves of six species[1] of California oaks by Mackie (1903) showed that some of them compared favorably with alfalfa hay. The ash (i.e. mineral) content of all species, however, was higher. One species (*Q. garryana*) approached alfalfa closely in protein content, the others averaging lower, being compared favorably in this respect with oat hay. Crude fiber showed wide variation but was higher in four species than in alfalfa. The ether extract (fats, waxes, chlorophyll, resins) of the oak leaves was considerably higher and tannins were present in much greater quantity. The carbohydrate and water content were both somewhat lower. Mackie concluded that oak leaves were less desirable than leguminous hay because of the presence of larger quantities of resins, waxes, tannins, and fiber, but for all that, he had no hesitation in recommending the oak browse for all classes of livestock.

Whether the results of such analyses as these may be applied directly to wildlife problems cannot at present be stated with certainty. It seems reasonable to infer, however, from the studies showing oak leaves to be palatable to so many kinds of browsing animals, and from the fact that palatability ratings for livestock and deer may often be the same, that wild as well as tame herbivores may profit more or less alike from this type of feed. How the tannins and waxes appeal to deer we do not know, but Columbian black-tailed deer appear to find *Quercus chrysolepis* highly palatable (Orr, 1937), although this oak contains more tannin than at least three of the species analyzed by Mackie. Deer appear to pay little attention to what we call bitterness in their choice of acorns for food.

An exclusive diet of oak browse is claimed to produce fatal sickness in cattle, although there is little or no danger of oak poisoning when the range is properly grazed (Dayton et al. 1937, Sampson, 1924), Whether a diet composed solely of oak leaves would result in death of deer seems to be an unsolved problem but under ordinary circumstances also one of relatively small moment.

## Analysis of Existing Records of Utilization

It is undoubtedly true that could more careful observations and studies be made on the utilization of oaks by wildlife, the number of birds and mammals known to participate might be increased to include a large percentage of the species and varieties in the United States. There would seem to be little reason to doubt, for instance, that all squirrels and chipmunks in this country feed upon acorns where they are available. Records are not so ex-

[1] *Q. garryana, Q. douglasii, Q. dumosa, Q. wislizenii, Q. chrysolepis, Q. kelloggii.*

tensive as they might be, doubtless because most field men are so accustomed to the idea that oaks are constantly used by many forms of wildlife, that they do not think of publishing notes on their observations.

Every statement as to oak utilization in the foregoing discussion and tabulation can be substantiated either by data in the files of the Section of Food Habits of the Biological Survey or by records published in the literature (given more fully in Tables 2 and 3). Systematic examination of food plant records accumulated by the author (Van Dersal, 1938a) has shown that while about 8 per cent of the woody species of the United States are known definitely to have been utilized by 6 or more kinds of animals, the remaining 92 per cent have records of only 5 or fewer—mostly fewer species.

Records of wildlife utilization of species of oaks as well as of other plants are incomplete primarily because proper identification was not made or could not be made at the time of observation. For stomach records, the specific determination of a mass of acorn meal is obviously difficult if not impossible, and for sight records in the field it must be acknowledged that separation of the many species of oaks may sometimes be beyond the powers of any but the specialist. In other words, there are very good reasons for the relative paucity of specific records. Unquestionably, however, a better series of observations might be compiled if observers would make more than a casual attempt to determine the species of oak upon which they find an animal feeding. A number of published studies prove this point (Dixon, 1934, Stegeman, 1937, Atwood and Steyermark, 1937). There are records of utilization of oak products by 94 kinds of birds (Table 4) and 92 kinds of mammals (Table 5), or a total of 186 kinds of vertebrates; of this number the data for 68 kinds of birds and 65 of mammals, or a total of 133, extend only to the genus. Thus the notes upon only 53 kinds of animals are available for indicating use of species. To some this may not seem a matter for regret since many engaged in wildlife management apparently have been content to believe that if the sum of the records for a given genus of plants is large, the chances are that any species in the genus could be used in wildlife plantings with good effect. The few applicable studies that have been made, however, seem to indicate that certain plants are more palatable to some or even to many kinds of wildlife, than are other species of the same genus. What these species are, and why they appeal to wildlife are questions that must eventually be answered if wildlife habitat improvement is to be put on an efficient basis.

Tables 4 and 5 summarize by orders the birds and mammals feeding upon parts of oaks. Among birds the large order Passeriformes accounts for 43 per cent of the records, and the Galliformes and Piciformes together for nearly as many more. These three groups and the Anseriformes contribute the bulk of the bird records. Among the mammals the preponderance of records assigned to the large order Rodentia is not surprising. The orders Carnivora and Artiodactyla, nearly equal in importance, taken together with the rodents provide most of the mammal records.

TABLE 2

SUMMARY OF FOOD UTILIZATION OF OAKS BY BIRDS

| *Bird*[2] | *Oak* | *Authority*[3] |
|---|---|---|
| Bob-white, Eastern | Quercus spp. | B.S., Davison '36, Butler '97, Handley in Stoddard '32, Martin '35, Errington '33, Gray '38 |
| | Q. alba | Judd, '05 |
| | Q. havardii | Ligon '27 |
| | Q. palustris | Judd '05 |
| | Q. phellos | B.S., Handley in Stoddard '32 |
| | Q. pumila | B.S., Handley in Stoddard '32 |
| | Q. nigra | B.S., Handley in Stoddard '32 |
| | Q. rubra | B.S., Handley in Stoddard '32 |
| | Q. virginiana | B.S., Handley in Stoddard '32 |
| Bob-white, Texan | Quercus sp. | Bendire '92 |
| Cardinal | Quercus sp. | B.S. |
| Chickadee | Quercus spp. | B.S., Audubon '35 |
| Chickadee, Mountain | Quercus sp. | B.S. |
| Crane | Quercus sp. | B.S. |
| Crane, Sandhill | Quercus sp. | Grinnell, Dixon, Linsdale '30 |
| Crow | Quercus sp. | B.S. |
| Crow, Fish, | Quercus sp. | B.S. |
| Duck, Black | Quercus sp. | B.S., Pirnie '35 |
| Duck, Wood | Quercus spp. | DeKay '44, Bailey '35, Warren '90, Anderson '07, Audubon '35, Roberts '36, Grinnell, Dixon, Linsdale '30 |
| | Q. borealis | B.S. |
| | Q. lobata | B.S., Grinnell, Dixon, Linsdale '30 |
| | Q. macrocarpa | King '83 |
| | Q. marilandica | B.S. |
| | Q. nigra | B.S. |
| | Q. palustris | B.S. |
| Finch, Purple | Quercus sp. | B.S. |
| Flicker | Quercus sp. | B.S. |
| Flicker, Gilded | Quercus sp. | B.S. |
| Flicker, Red-shafted | Quercus sp. | B.S. |
| Gadwall | Quercus spp. | Forbush '25, Roberts '36 |
| Golden-eye | Quercus sp. | B.S. |
| Goose, White-fronted | Quercus spp. | Roberts '36 |
| Grackle | Quercus sp. | B.S. |
| | Q. palustris | B.S. |
| Grackle, Boat-tailed, | Quercus sp. | B.S. |
| Grackle, Bronzed | Q. rubra | Wetmore '19 |
| Grackle, Purple | Quercus spp. | Audubon '31 |
| Grosbeak, Pine | Quercus spp. | Hausman '36 |
| Grosbeak, Rose-breasted | Quercus spp. | B.S., Butler '97 |
| | Q. stellata | McAtee '08 |
| Grouse, Sooty | Q. vaccinifolia | Belding '92 |
| Jay, Arizona | Quercus spp. | Bailey '28, '35 |
| Jay, Blue | Quercus spp. | B.S., DeKay '44, Warren '90, Bendire '95, Baird, Brewer, and Ridgway '74, Giraud '44, Audubon '35, Kennicott '57 |
| | Q. coccinea | Thoreau '10 |
| | Q. nigra | Lay and Siegler '37 |
| Jay, Blue-fronted | Quercus spp. | Baird, Brewer and Ridgway '74, Bailey '35, Wheelock '04 |
| Jay, California | Quercus spp. | B.S., Baird, Brewer and Ridgway '74, Nelson '75, Cooper '70, Grinnell, Dixon, Linsdale '30, Bailey '35, Vandenburgh '99 |

[2] Names of birds in this list correspond with the vernacular names of the A.O.U. Check List of North American Birds, Fourth Edition, 1931.

[3] Records in the files of the Biological Survey are indicated by B.S.

TABLE 2—*Continued*

| *Bird*[2] | *Oak* | *Authority*[3] |
|---|---|---|
| Jay, Florida | Quercus sp. | B.S. |
| Jay, Long-tailed | Quercus sp. | Grinnell, Dixon, Linsdale '30 |
| Jay, Northern blue | Quercus spp. | Roberts '36 |
| Jay, Piñon | Quercus spp. | Coues '74 |
| Jay, Rocky Mountain | Quercus spp. | Bailey '35 |
| Jay, Steller's | Quercus spp. | B.S, Audubon '35, Coues '74, Bendire '95, Nelson '75, Cooper '70 |
| Jay, Woodhouse's | Quercus spp. | B.S., Coues '74, Bailey '28, '35, Bendire '95 |
| Magpie | Quercus spp. | King '83 |
| Magpie, American | Quercus sp. | B.S. |
| Magpie, Yellow-billed | Quercus sp. | B.S. |
| Mallard | Quercus spp. | B.S., McAtee '18, Roberts '36, Pirnie '35 |
| | Q. alba | B.S. |
| | Q. lyrata | B.S. |
| | Q. virginiana | B.S. |
| Merganser, Hooded | Quercus sp. | B.S. |
| | Q. laurifolia | B.S. |
| Mourning dove | Quercus spp. | B.S., Dawson and Jones '03, Bendire '92 |
| Mourning dove, Western | Quercus spp. | Simmons '25 |
| Nutcracker, Clark's | Quercus spp. | Coues '74 |
| Nuthatch, White-breasted, | Quercus spp. | B.S., King '83, Maynard '81 |
| Parrot, Thick-billed | Q. arizonica | Wetmore '35 |
| | Q. diversicolor | Wetmore '35 |
| | Q. grisea | Wetmore '35 |
| | Q. hypoleuca | Wetmore '35 |
| Pheasant, Ring-necked | Quercus spp. | B.S., Roberts '36 |
| | Q. alba | Hosley '36, Hicks '36 |
| | Q. garryana | B.S., Leffingwell '31 |
| Pigeon, Band-tailed | Quercus spp. | B.S., Grinnell and Storer '24, Coues '74, Bendire '92, Cooper '70, Bailey '35, Belding '79, Sclater '12, Grinnell '13 |
| | Q. agrifolia | B.S., Grinnell '13 |
| | Q. chrysolepis | Grinnell '13 |
| | Q. emoryi | Willard '16 |
| | Q. garryana | B.S., Dawson and Bowles '09 |
| | Q. kelloggii | Grinnell '13 |
| | Q. lobata | B.S. |
| | Q. undulata | Musgrave '31 |
| | Q. wislizenii | Grinnell '13 |
| Pigeon, Viosca's | Q. grisea | Brewster '02 |
| Pintail, American | Quercus spp. | B.S., Bailey '35, Roberts '36 |
| Prairie chicken | Q. havardii | Ligon '27 |
| Prairie chicken, Greater | Quercus spp. | B.S., Gross '30, Schmidt '36, Roberts '36 |
| | Q. alba | B.S. |
| | Q. coccinea | B.S. |
| Prairie chicken, Lesser | Quercus sp. | B.S. |
| | Q. undulata | B.S. |
| Quail, California | Quercus sp. | B.S. |
| | Q. agrifolia | Linsdale '36 |
| Quail, Gambel's | Quercus sp. | B.S. |
| | Q. dumosa | fide D. M. Gorsuch |
| | Q. emoryi | fide D. M. Gorsuch |
| Quail, Mearns's | Quercus spp. | B.S., Judd '05 |
| | Q. dumosa | fide D. M. Gorsuch |
| | Q. emoryi | fide D. M. Gorsuch |
| Quail, Plumed | Quercus sp. | B.S. |
| Quail, Scaled, | Q. dumosa | fide D. M. Gorsuch |
| | Q. emoryi | fide D. M. Gorsuch |
| Red-head | Quercus spp. | Forbush '25, Roberts '36 |

TABLE 2—*Continued*

| *Bird*[2] | *Oak* | *Authority*[3] |
|---|---|---|
| Ruffed grouse, Eastern | Quercus spp. | B.S., Schmidt '36, Butler '97, Roberts '36 |
| | Q. alba | Judd '05, N.Y. State Conservation Dept. '32 |
| | Q. borealis | Judd '05 |
| | Q. ilicifolia | B.S. |
| | Q. prinoides | Judd '05 |
| Ruffed grouse, Gray | Quercus sp. | Seton '09 |
| Sapsucker | Q. agrifolia | McAtee '11 |
| | Q. alba | McAtee '11 |
| | Q. bicolor | McAtee '11 |
| | Q. borealis | McAtee '11 |
| | Q. breviloba | McAtee '11 |
| | Q. chapmanii | McAtee '11 |
| | Q. chrysolepis | McAtee '11 |
| | Q. coccinea | McAtee '11 |
| | Q. diversicolor | McAtee '11 |
| | Q. garryana | McAtee '11 |
| | Q. hypoleuca | McAtee '11 |
| | Q. imbricaria | McAtee '11 |
| | Q. laevis | McAtee '11 |
| | Q. laurifolia | McAtee '11 |
| | Q. leptophylla | McAtee '11 |
| | Q. lobata | McAtee '11 |
| | Q. lyrata | McAtee '11 |
| | Q. nigra | McAtee '11 |
| | Q. palustris | McAtee '11 |
| | Q. phellos | McAtee '11 |
| | Q. prinus | McAtee '11 |
| | Q. stellata | McAtee '11 |
| | Q. texana | McAtee '11 |
| | Q. toumeyi | McAtee '11 |
| | Q. undulata | McAtee '11 |
| | Q. velutina | McAtee '11 |
| | Q. virginiana | McAtee '11 |
| Sharp-tailed grouse | Quercus sp. | B.S. |
| | Q. coccinea | Judd '05 |
| Sharp-tailed grouse, Prairie | Quercus spp. | Schmidt '36, Sclater '12 |
| Sparrow, English | Quercus spp. | B.S., Richardson '38 |
| Sparrow, Fox | Quercus sp. | B.S. |
| Starling | Quercus sp. | B.S. |
| Teal, Green-winged | Quercus spp. | Ridgway '95, Roberts '36 |
| Thrasher, Brown | Quercus spp. | B.S., Hausmann '37, Skinner and Achorn '28 |
| Thrasher, California | Quercus sp. | B.S. |
| Thrush, Hermit | Quercus sp. | B.S. |
| Thrush, Varied | Quercus spp. | B.S., Dawson '23 |
| Titmouse, Oregon | Quercus sp. | Cooper '70 |
| Titmouse, Plain | Quercus sp. | B.S. |
| Titmouse, Tufted | Quercus sp. | Skinner and Achorn '28 |
| Towhee | Quercus spp. | B.S., Skinner and Achorn '28 |
| Towhee, Red-eyed | Quercus sp. | B.S. |
| Towhee, Spurred | Quercus sp. | B.S. |
| Turkey | Quercus spp. | B.S., DeKay '44, Dawson '03, Doan '88, Bendire '92 |
| | Q. alba | B.S., Blakey '37 |
| | Q. gambelii | Ligon '27 |
| | Q. marilandica | Blakey '37 |
| | Q. phellos | Blakey '37 |
| | Q. stellata | Blakey '37 |
| | Q. nigra | B.S. |
| | Q. palustris | B.S. |
| | Q. rubra | B.S. |

TABLE 2—*Continued*

| *Bird*[3] | *Oak* | *Authority*[4] |
|---|---|---|
| | Q. velutina | B.S. |
| | Q. virginiana | B.S. |
| Turkey, Eastern | Quercus spp. | Roberts '36 |
| Turkey, Merriam's | Quercus spp. | Bailey '28, Sclater '12 |
| Turkey, Mexican | Quercus spp. | Bendire '92 |
| Turkey, Rio Grande | Quercus spp. | Simmons '25 |
| Woodpecker, Ant-eating | Quercus sp. | B.S. |
| Woodpecker, Arctic three-toed | Quercus spp. | Forbush '25 |
| Woodpecker, Cabanis's | Quercus spp. | Bendire '95, Bailey '35, Wheelock '04 |
| Woodpecker, California | Quercus spp. | B.S., Belding '90, Fisher '06, Stephens '19, Baird, Brewer and Ridgway '74, Bailey '35, Dawson '23, Hoffman '27, VanDenburgh '99, Grinnell, Dixon, Linsdale '30 |
| | Q. agrifolia | fide R. M. Bond, Ritter '38 |
| | Q. chrysolepis | Stearns '82, Ritter '38 |
| | Q. douglasii | Ritter '38 |
| | Q. engelmannii | Ritter '38 |
| | Q. garryana | Ritter '38 |
| | Q. kelloggii | Michael '26, Ritter '38 |
| | Q. lobata | Ritter '38 |
| | Q. wislizenii | Ritter '38 |
| Woodpecker, Downy | Quercus spp. | B.S., Forbush '25 |
| Woodpecker, Eastern hairy | Quercus spp. | Roberts '36 |
| Woodpecker, Golden-fronted | Quercus spp. | Bailey '35 |
| Woodpecker, Hairy | Quercus spp. | B.S., Bendire '95, Dawson '23 |
| Woodpecker, Harris's | Quercus spp. | Wheelock '04 |
| Woodpecker, Ivory-billed | Quercus spp. | Bendire '95 |
| Woodpecker, Lewis's | Quercus spp. | B.S., Bendire '95, Bailey '35, Dawson '23 |
| | Q. agrifolia | fide R. M. Bond |
| | Q. garryana | Woodcock '02 |
| | Q. kelloggii | Michael '26 |
| Woodpecker, Mearns's | Quercus spp. | Bailey '28 |
| | Q. gambelii | fide G. Monson |
| Woodpecker, Northern downy | Quercus spp. | Roberts '36 |
| Woodpecker, Northern pileated | Quercus spp. | Knight '08, Bailey '35, Roberts '36 |
| Woodpecker, Pileated | Quercus spp. | DeKay '44, Bendire '95, Samuels '83, Audubon '35 |
| Woodpecker, Red-bellied | Quercus spp. | B.S., Forbush '25, Glover '66, Bendire '95, Bailey '35, Hausman '28, Roberts '36 |
| Woodpecker, Red-headed | Quercus spp. | B.S., Forbush '25, Knight '08, Bendire '95, Sclater '12 |
| Wren, Carolina | Quercus sp. | B.S. |

TABLE 3

SUMMARY OF FOOD UTILIZATION OF OAKS BY MAMMALS

| *Mammal*[4] | *Oak* | *Authority*[5] |
|---|---|---|
| Armadillo | Quercus sp. | B.S. |
| Bear | Quercus spp. | Dayton '31 |
| | Q. garryana | Jepson '10 |
| | Q. sadleriana | Dayton '31 |
| Bear, Black | Quercus spp. | Bailey '25, Grinnell, Dixon, Linsdale '37 |
| | Q. alba | Kennicott '59 |
| | Q. gambelii | fide G. Monson |
| Bear, New Mexico black | Quercus spp. | Bailey '05, '31 |

[4] Names of mammals correspond with those given in H. E. Anthony's "Field Book of North American Mammals," 625 pp. New York, 1928.

[5] Records in the files of the Biological Survey are indicated by B.S.

TABLE 3—*Continued*

| *Mammal*[4] | *Oak* | *Authority*[4] |
|---|---|---|
| Bear, Olympic black | Quercus spp. | Bailey '36 |
| Beaver | Quercus spp. | Bailey '22, Warren '28 |
| | Q. alba | Atwood '38 |
| | Q. borealis | Atwood '38 |
| | Q. coccinea | Atwood '38 |
| | Q. muhlenbergii | Atwood '38 |
| Cat, Ring-tailed | Quercus spp. | Grinnell, Dixon, Linsdale '37 |
| Chickaree, Douglas | Quercus spp. | Bailey '36, Seton '29 |
| Chickaree, Sierra | Quercus spp. | Bailey '36 |
| Chipmunk, Allen | Quercus spp. | Bailey '36 |
| Chipmunk, Arizona | Quercus spp. | Bailey '31 |
| Chipmunk, Eastern | Quercus spp. | B.S. Howell '21, Hahn '09, Bailey '23, Evermann and Clark '11, Anthony '17, '28, Kennicott '57 |
| Chipmunk, Gila | Quercus spp. | Bailey '31 |
| | Q. emoryi | Mearns '07 |
| Chipmunk, Golden | Quercus spp. | Bailey '36 |
| Chipmunk, Gray | Quercus spp. | Bailey '26 |
| Chipmunk, Gray eastern | Quercus spp. | Cory '12, Bailey '29 |
| Chipmunk, Gray-footed | Quercus spp. | Bailey '05, '31 |
| Chipmunk, Gray-necked | Quercus spp. | Bailey '31 |
| | Q. gambelii | Bailey '31 |
| Chipmunk, Hopi | Quercus spp. | Bailey '31 |
| Chipmunk, Larger Colorado | Quercus spp. | Bailey '31 |
| Chipmunk, Lesser Colorado | Quercus spp. | Bailey '31 |
| Chipmunk, Little northern | Quercus spp. | Bailey '26 |
| Chipmunk, Lyster | Quercus spp. | Audubon and Bachman '46 |
| Chipmunk, Merriam | Quercus spp. | Mearns '07 |
| Chipmunk, Pale | Quercus spp. | Bailey '26 |
| Chipmunk, Say | Quercus spp. | Warren '10 |
| Chipmunk, Siskiyou | Quercus spp. | Bailey '36 |
| Chipmunk, Townsend | Quercus spp. | Bailey '36 |
| Chipmunk, Western | Quercus spp. | Anthony '17 |
| Deer, Black-tailed | Quercus spp. | B.S., Anthony '17, '28, Hall '27 |
| | Q. kelloggii | Russell '32 |
| | Q. utahensis | B.S. |
| | Q. undulata | Musgrave '31 |
| Deer, California mule | Quercus spp. | Grinnell and Storer '24 |
| | Q. agrifolia | Robinson '37 |
| | Q. chrysolepis | Robinson '37, Dixon '34 |
| | Q. douglasii | Robinson '37, Dixon '34 |
| | Q. dumosa | Robinson '37, Dixon '34 |
| | Q. engelmannii | Robinson '37 |
| | Q. kelloggii | Robinson '37, Dixon '34 |
| | Q. lobata | Dixon '34 |
| | Q. vaccinifolia | Dixon '34 |
| | Q. wislizenii | Dixon '34, Robinson '37 |
| Deer, Columbian black-tailed | Quercus spp. | Hall '27, Coffman '20, Bailey '36 |
| | Q. chrysolepis | Orr '37 |
| Deer, Louisiana white-tailed | Quercus sp. | B.S. |
| Deer, Mexican mule | Q. emoryi | Mearns '07 |
| Deer, Northern white-tailed | Quercus spp. | Rhoads '03 |
| | Q. borealis | Howard '37, Aldous and Smith '38 |
| Deer, Rocky Mountain black-tailed | Quercus spp. | Dayton '31 |
| | Q. garryana | Robinson '37 |
| | Q. vaccinifolia | Dixon '34, Russell '32 |
| Deer, Sonora white-tailed | Q. alba | Nichol '38 |
| | Q. arizonica | Nichol '38 |
| | Q. emoryi | Nichol '38 |
| | Q. gambelii | Nichol '38 |
| | Q. grisea | Bailey '05 |
| | Q. hypoleuca | Nichol '38 |
| | Q. oblongifolia | Nichol '38 |

TABLE 3—*Continued*

| *Mammal*[4] | *Oak* | *Authority*[5] |
|---|---|---|
| Deer, Texan white-tailed | Quercus spp. | Bailey '05 |
| Deer, Virginia | Quercus sp. | B.S. |
| | Q. borealis | B.S. |
| | Q. marilandica | B.S. |
| | Q. prinus | B.S. |
| Deer, White-tailed | Quercus spp. | Anthony '17, Hahn '09, Schilling '38 |
| | Q. alba | Hosley '36, Atwood and Steyermark '37, Schilling '38, Stegeman '37 |
| | Q. borealis | Hosley '36, Atwood and Steyermark '37, Hosley and Ziebarth '35, Stegeman '37 |
| | Q. coccinea | Atwood and Steyermark '37, Clepper '31, Stegeman '37 |
| | Q. macrocarpa | Atwood and Steyermark '37 |
| | Q. marilandica | Atwood and Steyermark '37 |
| | Q. montana | Stegeman '37 |
| | Q. stellata | Atwood and Steyermark '37 |
| | Q. undulata | Musgrave '31 |
| | Q. velutina | Atwood and Steyermark '37, Schilling '38 |
| Elk | Quercus spp. | Baldwin and Patton '38, Greffenius '38 |
| | Q. borealis | Baldwin and Patton '38 |
| | Q. coccinea | Baldwin and Patton '38 |
| | Q. gambelii | Roberts '30 |
| Fox, Gray | Quercus sp. | B.S. |
| | Q. phellos | B.S. |
| Fox, Red | Quercus spp. | Hamilton '35, Murie '36 |
| Hare, Varying | Quercus spp. | Hosley '36 |
| Hare, Minnesota varying | Q. macrocarpa | Criddle '38 |
| Moose | Q. borealis | Murie '34 |
| Mouse, Gambel white-footed | Quercus spp. | Bailey '36 |
| Mouse, Gapper red-backed | Quercus spp. | Hatt '30 |
| Mouse, Northern white-footed | Quercus spp. | Cory '12, Kennicott '57, Stoner '18, Brayton '82 |
| Mouse, Ord meadow | Quercus spp. | Stoner '18, Hatt '30 |
| Mouse, Pine | Q. alba | Kennicott '57 |
| | Q. macrocarpa | Kennicott '57 |
| Mouse, Redwood white-footed | Quercus spp. | Bailey '36 |
| Mouse, Rowley white-footed | Quercus spp. | Bailey '31 |
| Mouse, Tawny white-footed | Quercus spp. | Bailey '31 |
| Mouse, White-footed | Q. tomentella | fide R. M. Bond |
| Muskrat | Quercus sp. | B.S. |
| Opossum | Quercus spp. | B.S., Brayton '82 |
| Opossum, Virginia | Quercus spp. | Howell '21 |
| Peccary | Quercus spp. | Mearns '07, Anthony '17 |
| | Q. havardii | Ligon '27 |
| Porcupine | Quercus spp. | Taylor '35 |
| | Q. utahensis | B.S. |
| Porcupine, Arizona | Q. grisea | Bailey '31 |
| Rabbit, Cottontail | Quercus spp. | Allen '38 |
| | Q. alba | Hosley '36 |
| | Q. borealis | Hosley '36 |
| | Q. palustris | Todd '27 |
| | Q. prinoides | Todd '27 |
| | Q. prinus | Hosley '35 |
| | Q. velutina | Hosley '35 |
| Rabbit, Mearns's cottontail | Quercus spp. | Siegler '37 |
| | Q. rubra | Hendrickson '38 |
| Raccoon | Quercus spp. | B.S., Grinnell, Dixon, Linsdale '37, Hamilton '36, Bailey '26, Hahn '09 |
| Raccoon, Eastern | Quercus spp. | Bailey '23 |
| Raccoon, Mexican | Quercus spp. | Bailey '31 |
| Raccoon, Northwestern | Quercus spp. | Bailey '36 |

TABLE 3—*Continued*

| *Mammal*[4] | *Oak* | *Authority*[5] |
|---|---|---|
| Rat, Allegheny wood | Quercus spp. | Bailey '23 |
| Rat, Colorado bushy-tailed wood | Quercus spp. | Bailey '31 |
| Rat, Colorado wood | Quercus spp. | Bailey '31 |
| Rat, Dusky-footed wood | Q. agrifolia | Vestal '38, Bailey '36 |
| | Q. garryana | English '23 |
| Rat, Mexican wood | Quercus spp. | Bailey '31 |
| Rat, Portola wood | Quercus sp. | Parks '22 |
| Rat, White-throated wood | Quercus spp. | Bailey '31 |
| Skunk, Eastern | Quercus spp. | B.S. |
| Squirrel, Abert | Quercus spp. | Bailey '31, Seton '09 |
| Squirrel, Apache | Q. hypoleuca | Mearns '07 |
| Squirrel, Arizona gray | Quercus spp. | Bailey '31 |
| Squirrel, Beechey ground | Quercus spp. | Merriam '10, Grinnell and Storer '24 |
| Squirrel, Black-backed rock | Quercus spp. | Bailey '05 |
| Squirrel, Carolina fox | Quercus spp. | Howell '21 |
| Squirrel, Colorado rock | Quercus spp. | Warren '10 |
| Squirrel, Couch rock | Quercus spp. | Bailey '05 |
| | Q. emoryi | Bailey '05 |
| Squirrel, Douglas ground | Quercus spp. | Howell '38, Edge '35 |
| | Q. garryana | Edge '35 |
| Squirrel, Eastern gray | Quercus spp. | Seton '09, Anthony '17 |
| Squirrel, Flying | Quercus spp. | Seton '09, Howell '18 |
| Squirrel, Fox | Quercus spp. | Seton '09, Baumgartner '38 |
| Squirrel, Golden mantled ground | Quercus spp. | Bailey '36 |
| Squirrel, Gray | Quercus spp. | B.S., Howell '21, Grinnell, Dixon, Linsdale '30 |
| | Q. coccinea | Nichols '27 |
| Squirrel, Huachuca gray | Quercus spp. | Seton '09 |
| Squirrel, Mantled ground | Quercus spp. | Howell '38 |
| Squirrel, Merriam gray | Quercus spp. | Bailey '26, '29 |
| Squirrel, Northern gray | Quercus spp. | Cory '12, Stoner '18, Rowley '02 |
| Squirrel, Red | Quercus spp. | Bailey '26, Seton '09, Kennicott '57 |
| | Q. alba | Klugh '27 |
| | Q. borealis | Klugh '27 |
| | Q. macrocarpa | Klugh '27 |
| Squirrel, Rock | Quercus spp. | Bailey '31, Cary '11, Howell '38, Mearns '07, Anthony '28 |
| Squirrel, Say ground | Quercus spp. | Warren '10, Bailey '37 |
| Squirrel, Small eastern flying | Quercus sp. | B.S., Stoner '18, Hahn '09 |
| Squirrel, Southern red | Quercus spp. | Cory '12, Stoner '18, Bailey '23, Schmidt '31 |
| Squirrel, Thirteen-striped | Quercus spp. | Stoner '18, Bailey '93 |
| | Q. macrocarpa | Howell '38 |
| Squirrel, Tuft-eared | Quercus spp. | Bailey '31, Anthony '17 |
| Squirrel, Utah rock | Quercus spp. | Warren '10 |
| Squirrel, Walnut rock | Quercus spp. | Bailey '31 |
| Squirrel, Western fox | Quercus spp. | Bailey '05, Stoner '18, Hahn '09 |
| Squirrel, Western gray | Quercus spp. | Bailey '36, Seton '09, Anthony '17, Grinnell and Storer '24 |

The reader may have noted apparent duplications in Tables 2 and 3; thus "bear" may seem to include black bear, as well as New Mexico black bear. For the purposes of Tables 4 and 5, however, records indefinite as to animal species are not tabulated.

Further analysis of the records, with respect to 85 species of oaks of the United States shows (Table 6)[6] that 35 species are not recorded at all. Thus we do not know definitely whether birds and mammals utilize about 40 per cent of the species of Quercus. We

[6] The classification of oaks adopted is that of Trelease (1924), with a few additions and amendments. All species usually classed as hybrids are omitted.

suppose they do for there is every good reason except direct evidence to make us think so. Fourteen species have one record, 8 species have two, 4 have three, 11 have four, 5 have five, 3 have six, 3 have seven, and 1 each has eight, nine, eleven, and fourteen records. The species with records of utilization by 5 or more kinds of animals are about equally divided between the eastern United States and California, that is they occur in parts of the United States with the greatest numbers of interested observers. The data, therefore, reflect potential observing power rather than anything convincing as to palatability of the foods. The same thing has already been noted with regard to the red cedar (*Juniperus virginiana*) which has the greatest record of any single species of woody plant (Van Dersal, 1938b). Hosley (1936) has pointed out that we lack a great deal of what would seem to be rather easily obtainable information on food value of the hardwoods in general. It would undoubtedly have startled some of the naturalists of a half or whole century ago if they could have realized as they recorded observations upon the utilization of acorns by some animal or other, that for the next 50 or 100 years no one else

TABLE 4
SPECIES OF VARIOUS ORDERS OF BIRDS FEEDING ON OAK PRODUCTS

| Order | Birds | | Groups |
|---|---|---|---|
| | Number | Per cent | |
| Anseriformes | 10 | 10 | Ducks, geese |
| Galliformes | 18 | 19 | Grouse, quail, pheasants, turkeys |
| Gruiformes | 2 | 2 | Cranes |
| Columbiformes | 4 | 4 | Doves, pigeons |
| Psittaciformes | 1 | 1 | Parrot |
| Piciformes | 20 | 21 | Flickers, woodpeckers |
| Passeriformes | 39 | 43 | Crows, jays, titmice, nuthatches, wrens, thrashers, thrushes, starlings, grosbeaks, sparrows, finches, grackles, chickadees, magpies, towhees |
| Totals | 94 | 100 | |

TABLE 5
SPECIES OF VARIOUS ORDERS OF MAMMALS FEEDING ON OAK PRODUCTS

| Order | Mammals | | Groups |
|---|---|---|---|
| | Number | Per cent | |
| Marsupialia | 1 | 1 | Opossum |
| Carnivora | 9 | 10 | Bears, foxes, raccoons, ring-tailed cat, skunks |
| Rodentia | 66 | 72 | Squirrels, chickarees, chipmunks, porcupines, wood-rats, muskrat, ground squirrels |
| Lagomorpha | 3 | 3 | Hare, cottontail |
| Artiodactyla | 12 | 13 | Deer, elk, moose |
| Xenarthra | 1 | 1 | Armadillo |
| Totals | 92 | 100 | |

would publish a similar record.

The other genera of woody plants are in no better state than Quercus with respect to records of utilization by wildlife, and for the present the only course open is to make full use of the data on hand. Few publications suggesting outstanding species to plant for the encouragement of wildlife list the oaks. Yet it is obvious that they should figure largely in any program involving the treatment or use of vegetation for wildlife benefit, wherever their use is ecologically correct.

TABLE 6

NUMBER OF ANIMALS UTILIZING SPECIES OF OAKS

| *Species of oak* | *Animals utilizing* | *Species of oak* | *Animals utilizing* | *Species of oak* | *Animals utilizing* |
|---|---|---|---|---|---|
| Q. agrifolia | 7 | Q. grisea | 4 | Q. palustris | 6 |
| Q. alba | 14 | Q. gunnisonii | 0 | Q. pauciloba | 0 |
| Q. arizonica | 2 | Q. havardii | 3 | Q. phellos | 4 |
| Q. arkansana | 0 | Q. hypoleuca | 4 | Q. pricei | 0 |
| Q. bicolor | 1 | Q. ilicifolia | 1 | Q. prinoides | 2 |
| Q. borealis | 11 | Q. imbricaria | 1 | Q. prinus | 3 |
| Q. boyntonii | 0 | Q. intricata | 0 | Q. pumila | 1 |
| Q. brayi | 0 | Q. kelloggii | 5 | Q. rubra | 4 |
| Q. breviloba | 1 | Q. laevis | 1 | Q. rydbergiana | 0 |
| Q. canbyi | 0 | Q. laurifolia | 2 | Q. sadleriana | 2 |
| Q. chapmanii | 1 | Q. leptophylla | 1 | Q. shrevei | 0 |
| Q. chrysolepis | 5 | Q. livermorensis | 0 | Q. shumardii | 0 |
| Q. cinerea | 0 | Q. lobata | 4 | Q. stellata | 4 |
| Q. coccinea | 8 | Q. lyrata | 2 | Q. submollis | 0 |
| Q. confusa | 0 | Q. macrocarpa | 6 | Q. subturbinella | 0 |
| Q. diversicolor | 2 | Q. margaretta | 0 | Q. texana | 1 |
| Q. douglasii | 2 | Q. marilandica | 4 | Q. tharpii | 0 |
| Q. dumosa | 4 | Q. media | 0 | Q. tomentella | 1 |
| Q. durandii | 0 | Q. mohriana | 0 | Q. toumeyi | 1 |
| Q. eastwoodiae | 0 | Q. montana | 1 | Q. undulata | 5 |
| Q. ellipsoidalis | 0 | Q. muhlenbergii | 1 | Q. utahensis | 2 |
| Q. emoryi | 7 | Q. myrtifolia | 0 | Q. vaccinifolia | 3 |
| Q. engelmanii | 2 | Q. nigra | 5 | Q. velutina | 4 |
| Q. fendleri | 0 | Q. novomexicana | 0 | Q. venustula | 0 |
| Q. gambelii | 6 | Q. nuttallii | 0 | Q. virginiana | 4 |
| Q. garryana | 9 | Q. oblongifolia | 1 | Q. vreelandii | 0 |
| Q. georgiana | 0 | Q. obtusifolia | 0 | Q. wilcoxii | 0 |
| Q. grandidentata | 0 | Q. palmeri | 0 | Q. wislizenii | 3 |
| Q. gravesii | 0 | | | | |

## AVAILABILITY OF ACORNS

Although there is good reason to conclude from assembled data that oaks provide staple food for wildlife, in common with most other woody plants, their fruits are produced seasonally. During the fall and early winter utilization would be presumed to reach a peak, and studies of animal diets confirm this expectation. However, acorns are sometimes available for a much longer period. According to Handley (Stoddard, 1932) bob-whites were utilizing acorns up to 16 per cent of their diet as late as April, and except for May and September had eaten some in every month. Reports show, moreover, that fruits far more likely to rot than acorns are often found and eaten by birds in late spring. If grapes and cherries last so long, there would seem to be no reason why acorns should not also persist. In general, however,

acorns are a fall and early winter food.

The "uncertainty" of acorn crops has often been alleged. In this connection McClennen (1939) made an interesting study that merits mentio Wood in 1934 had recorded that 22 oı 55 oak trees produced no seed during a three-year period and had concluded that some trees yield little or no seed while others periodically make good crops. McClennen continued Wood's observations later, and published the table reproduced here as Table 7. According to McClennen, the two chestnut oak trees look much alike, and are growing about four chains apart. Tree No. 4 has 0.6″ advantage in diameter but appears somewhat less vigorous. From this table it may be seen that one tree has yielded a good seed crop every two years, with poor ones in between. The other tree, in 10 years, has never produced a good crop.

TABLE 7
ACORN CROPS OF TWO INDIVIDUAL TREES (*QUERCUS MONTANA*)

| Year | Number of cups | |
|---|---|---|
| | Tree number 22 | Tree number 4 |
| 1928 (20 sq. ft. only) | 67 (2,010) | 8 (282) |
| 1929 | No count made | |
| 1930 (Entire crop) | 926 | 53 |
| 1931 " " | 34 | 0 |
| 1932 " " | 509 | 0 |
| 1933 " " | 107 | 0 |
| 1934 " " | 805 | 0 |
| 1935 " " | 63 | 0 |
| 1936 " " | 1,197 | 18 |
| 1937 " " | 66 | 20 |
| 1938 " " | 697 | 16 |
| Nine-year average | 641.4 | 38.9 |

Nearly simultaneous observations over large areas on the fruiting of many kinds of woody plants has led the author to believe that the climatic factors presumably responsible for much variation in seed abundance are scarcely less operative on the flowering and fruiting of other woody plants than on the oaks. Insect destruction of acorns might seem to account for uncertainties in the crops but insect injury to acorns certainly has its parallel in similar injury to fruits of other woody plants. Korstian (1927) found an average of 27 per cent of the acorns of several species of black oaks to be destroyed by insects and for white oaks the figure was 10 per cent. Chestnut oak acorns were found to be uninjured, while the black oak acorns were damaged more than 50 per cent. For the present, at least, while acorn production must be considered as relatively uncertain, the oaks may be presumed to be as certain in bearing as are many other groups of woody plants.

A possible objection to the use of oaks in planting programs would be that the trees are slow-growing, and for some species that is undoubtedly true. Yet it would be surprising indeed if all the 85 species were uniform in this respect. The author has seen annual rings in a southern red oak that averaged almost an inch in thickness for over 15 years; in central West Virginia growth rings of the white oak may be at least one-half inch thick and in central Maryland the pin oak may reach a diameter of as much as 13 inches in 10 years. The relatively rapid growth rate of *Q. virginiana* also is well known in the South. Many of the so-called scrub oaks (as *Q. ilicifolia*) are as rapid growing as numerous other woody plants. Smith (1929) has pointed out also that there are wide variations

between individual growth rates within a species.

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SUMMARY

1. In view of the great ecological importance of oaks, their widespread distribution, and substantial silvicultural values, their extensive utilization for food by wildlife is recorded.

2. Present accumulations of records show that 186 different kinds of birds and mammals feed on oak products. Acorns have been recognized as preferred or staple foods of a great many of these animals, and oak browse is shown to be of outstanding importance to wild herbivores.

3. Although the present record of wildlife utilization of oaks is greater than that for any other genus of woody plants, 40 per cent of the oaks have no records attached to them at all, *as species*. And of the 186 kinds of animals listed as feeding on oaks, only 53 are known to feed on oaks identified to species. In other words, while there is a substantial quantity of data available it is much less exact than is necessary to determine whether some of the 85 native oaks are of greater importance to wildlife than others.

4. On the basis of the data presented, it is reasonable to conclude that use of staple food plants, such as oaks, in plantings made to improve wildlife habitats is worthy of more consideration than it has thus far received.

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William R. Van Dersal
Soil Conservation Service
Washington, D. C.

# NOTES ON THE FOOD AND PARASITES OF THE RABBITS OF A LOWLAND AREA IN OKLAHOMA[1]

*Charles C. Smith*

During December and January of 1939–40, the rabbits of a lowland area along the South Canadian River in Cleveland County, Oklahoma were under observation. Two species were present: a swamp rabbit, *Sylvilagus a. aquaticus*, and a cottontail, *Sylvilagus floridanus alacer*. The swamp rabbits were confined to lowland areas like that studied while the cottontails were only winter residents. Cottontails were abundant in the surrounding upland.

Most years fall rains promote the growth of seedlings of herbs such as *Aster praealtus*, *Solidago missouriensis*, and *Melilotus alba* which supply a part of the winter diet of rabbits of both species. Patches of clover in protected spots are eagerly eaten during the winter. In addition, twigs of willow, cottonwood, Baccharis, Tamarix, and *Amorpha fruticosa* are extensively browsed, especially by the swamp rabbits. Larger stems are barked while those the size of a lead pencil and smaller are usually entirely consumed. Although Johnson grass, Bermuda grass, and *Panicum virgatum* are abundant in places, they are not much utilized as food during the winter months. The cottontails eat more of the grasses than do the swamp rabbits.

The fall of 1939 was unusually dry and the rank growth of vegetation following the spring rains was entirely dead and dry long before frost. The seedlings usually present in the fall and winter were absent. Sweet clover patches that usually had a green undergrowth of seedlings in the fall were entirely lacking in the fall of 1939.

Close attention was paid to the stomach contents of the rabbits examined. Location of fecal pellets in the field was also noted since these are often a clue to the feeding sites of the animals. All evidence points to a diet for both species consisting largely of bark and twigs of woody plants. Of particular interest was the eating of the taproots of sweet clover plants by rabbits of both species. These plants were very tall and in the autumn and winter tended to fall over. In some cases this lodging was hastened by undermining by the rabbits.

## Parasites

Forty-two rabbits, 31 cottontails and 11 swamp rabbits, were collected over an eight-week period and examined for nematodes and cestodes parasitic in the digestive tract. The results are summarized in the following text and in Table 1.

*Obeliscoides cuniculi*, red stomach worm. These slender worms were found attached to, or imbedded in, the stomach mucosa of the majority of the swamp rabbits. Often more than a hundred worms were present in a single stomach. None were found in the cottontails.

*Trichostrongylus calcaratus*, intestinal worm. This species of nematode was

[1] Contribution No. 224 from the Zoological Laboratories of the University of Oklahoma.

TABLE 1

PERCENTAGE OF INFESTATION AND AVERAGE NUMBER OF EACH PARASITE IN INFECTED SPECIMENS OF TWO SPECIES OF RABBITS

| Parasite | Cottontail | | Swamp Rabbit | |
|---|---|---|---|---|
| | Percentage infestation | Number per host | Percentage infestation | Number per host |
| Obeliscoides cuniculi | 0 | 0 | 81.7 | 100 |
| Trichostrongylus calcaratus | 77.4 | 15 | 54.3 | 20 |
| Passalurus ambiguus | 0 | 0 | 9 | 500 |
| Trichuris leporis | 6.4 | 1 | 27.2 | 1.5 |
| Cittotaenia ctenoides | 87.1 | 2.5 | 100 | 4 |
| Cysticercus pisiformis | 74.1 | 8.5 | 0 | 0 |
| Multiceps serialis | 6.4 | 1 | 0 | 0 |

found in the large intestine of nearly all the specimens of both species of rabbits. The numbers per specimen varied from a few to more than fifty. There seemed to be no significant difference in degree of infestation of the two species.

*Passalurus ambiguus*, pin-worm. Pin-worms were found in only one specimen, a swamp rabbit. This individual was emaciated and its entire alimentary tract more or less inflamed. A lesion was present in the rectum and at this point were hundreds of the pin-worms.

*Trichuris leporis*, whip-worm. One or two specimens of this worm were found in each of three swamp rabbits and two cottontails.

*Cittotaenia ctenoides*, rabbit tapeworm. Over a hundred specimens of this species were taken from the small intestines of the rabbits. Few animals were free of this parasite and the heaviest infestation was ten worms in one animal. The two species of rabbits were infested to about the same degree.

*Cysticercus pisiformis*, larval dog tapeworm. Most of the cottontails were infested with the larval stage of *Taenia pisiformis*, a tapeworm of the dog and coyote. These bladder worms were located chiefly on the rectum of each infected animal although some were found attached to all organs. In many cottontails, cysts were present in the liver but none were found in the livers of the swamp rabbits. That the latter animals should be free of this parasite at this time seems surprising in view of the fact that the cottontails were so heavily infested. The explanation may be that the alternate hosts do not frequent the territory occupied by the swamp rabbits to any great extent.

*Multiceps serialis*, many-headed bladder worm. One cyst of this tapeworm of the dog was found in the muscle of the hind leg of a cottontail and another in the shoulder of another specimen of the same species. These cysts are not common in the cottontails of this region but are frequent in jackrabbits.

Ward (1934) listed the nematodes and cestodes from fifty-two cottontails and four swamp rabbits taken in central Oklahoma. His data concerning the species of parasites dealt with in this paper are presented in Table 2. Ward's collections represented several stations while the writer's material was all obtained in a restricted area. Apparently the degree of parasitism in rabbits of

this community was much higher in 1939–40 than in those studied by Ward in 1933.

TABLE 2

PERCENTAGE OF INFESTATION BY VARIOUS PARASITES OF TWO SPECIES OF RABBITS IN CENTRAL OKLAHOMA. DATA FROM WARD (1934)

| *Parasite* | *Swamp rabbit* | *Cottontail* |
|---|---|---|
| Obeliscoides cuniculi | 50 | 30 |
| Trichuris leporis | 50 | 0 |
| Passalurus ambiguus | 0 | 23 |
| Cittotaenia ctenoides | 25 | 27 |
| Cysticercus pisiformis | 50 | 61.5 |

Harkema (1936) found that cottontails in North Carolina showed 78 per cent infestation with Cittotaenia, 31.7 per cent with larval *Taenia pisiformis*, 70.73 per cent with the stomach worm (*Obeliscoides cuniculi*), and 84.48 per cent with *Trichostrongylus calcaratus*. Morgan and Waller (1940) conducted a survey of the parasites of the Iowa cottontail and found 36 per cent infested with Cittotaenia, 41 per cent with *Cysticercus pisiformis*, 21.9 per with whip-worms, 21 per cent with *Trichostrongylus calcaratus*, and 11.9 per cent infested with red stomach worms.

## SUMMARY

(1) The summer ranges of two species of rabbits (*Sylvilagus floridanus alacer* and *Sylvilagus a. aquaticus*) in Cleveland County, Oklahoma are distinct but in the winter the lowland areas to which the swamp rabbits are restricted are invaded by cottontails. The fall drought of 1939 caused the cottontails to migrate into the low areas much earlier and to a considerably greater extent than usual.

(2) Winter food habits of the two species were similar in that both fed largely on bark and twigs. The cottontail utilized some dry grass as food while both species supplemented their diet with the roots of sweet clover.

(3) Both species showed a high percentage of infestation with the rabbit tapeworm (*Cittotaenia ctenoides*) while only the cottontails harbored larval dog tapeworms (*Cysticercus pisiformis*). The red stomach worm (*Obeliscoides cuniculi*) was limited to the swamp rabbits while *Trichostrongylus calcaratus* was present in a high percentage of both species. Two larvae of *Multiceps serialis*, the many-headed bladderworm stage of a dog tapeworm were found in the cottontails. This form usually is restricted to the jackrabbit.

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Charles C. Smith
Department of Zoology
University of Oklahoma
Norman, Oklahoma

# FOOD HABITS OF THE SHARP-TAILED GROUSE BY ANALYSIS OF DROPPINGS[1]

*Gustav Swanson*

Although the analysis of fecal droppings was reported by Dalke (1935) as a very promising method of food habits study, and Wilson and Vaughn (1936) mention using it on quail, it has not since received the recognition it dedeserves for application to gallinaceous birds.

The technique has, however, been used in numerous studies of predatory mammals. Dearborn (1932) published the first comprehensive food habits study based on analysis of feces, applying the method to 9 species of predatory furbearers in Michigan. Hamilton (1933) studied the food habits of the big brown bat by use of the dropping-analysis method. O. J. Murie (1935) and Bond (1939) have used the method extensively on coyotes. Errington (1935, 1937a), Hamilton (1935), Hamilton, Hosley, and MacGregor (1937), and A. Murie (1936), have all applied it to the red fox. It has been adapted to study of the food habits of skunks by Hamilton (1936), Kelker (1937), Selko (1937), and Wight (1938). Errington has also used the method on badger (1937) and weasel (1936), and Giles (1939) has applied it to the raccoon in Iowa.

Possibly the greater ease of obtaining game bird stomachs accounts for the neglect of the dropping analysis method in studies of the group even though it can probably be applied as successfully to the gallinaceous birds as to carnivorous mammals. Admittedly the study of stomach contents has many advantages, including particularly the greater ease of identifying undigested items, and the fact that the comparative volumes of foods may be more accurately determined.

The contents of droppings do not represent foods in the volumes in which they were eaten, and some items may be so thoroughly digested as to be unidentifiable. These, however, are likely to be very few in the case of gallinaceous birds. Practically anything eaten by these birds will have recognizable remnants in the feces; moreover the method is the only one available for following the food habits of a group of birds through a considerable period, and for birds too scarce to allow the sacrifice of any for stomach examinations. Fecal analysis would seem particularly valuable also for early determination of the food predilections of an exotic species being introduced at considerable expense and at first under entire protection.

The data here reported resulted from the study of 550 droppings of the sharp-tailed grouse (*Pedioecetes phasianellus campestris*) obtained by Marius Morse in October and early November, 1938, in Hubbard County, Minnesota. The droppings were collected periodically from the same locality, and were fresh enough to justify the assumption that they represented foods taken by the birds in those two months.

[1] Paper No. 1789 Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul. Some assistance in the present study was received from Work Projects Administration Official Project No. 65-1-71-140.

In attempting to decide what would be the best method of presenting the data, the previously noted mammal dropping-analyses were reviewed. Dearborn used the volumetric system in most of his analyses, but presents data for some species on the frequency-of-occurrence basis, and states that "both reflect with a fair degree of accuracy the relative proportion of the different items." Hamilton is consistent in the use of frequency of occurrence throughout his several papers cited. O. J. Murie (1935) and Bond give percentages based on total number of prey individuals, and Bond in addition states the frequency of occurrence in scats. Kelker uses the volumetric method, and Selko cites volume as well as frequency. In the papers cited Errington sometimes presents volumetric data, sometimes frequency, and in at least one case both. Giles uses both frequency and volumetric data, and goes further than any of the other authors in attempting to estimate the original volume of prey taken.

A local food habits study is of greater value if it can be compared directly with others on the same species, but lack of uniformity in treatment makes this difficult. In feces-analyses, as well as stomach and pellet studies, it is always possible to determine frequency of occurrence of items that can be identified at all and since in many cases volume and number of food items taken may be more difficult to determine, the frequency-of-occurrence indices should always be presented so that some comparison with other studies will be possible.

Often both volumetric determinations and the counting of food items are impossible or impractical, but where one or both can be accomplished, the value of the study for comparison with others is greatly enhanced. The frequency-of-occurrence and number-of-individuals methods tend to overemphasize the items that are small and widely distributed over the animal's feeding range, especially foods that are hard. The volumetric method, in feces-analyses as well as stomach content studies, certainly gives the best indication of which foods furnished the bulk of the animal's sustenance. Any method, with the possible exception of crop-content studies, tends to discriminate against soft or amorphous foods, but this cannot be helped. It seems clear that the best presentation of food habits data is a combination of as many of the above-mentioned methods as it is feasible to employ.

In the table of sharp-tailed grouse foods which follows, it will be noted that frequency-of-occurrence alone tends to exaggerate the importance of such forms as *Polygonum*, *Symphoricarpos*, and *Chenopodium*.

This small list of plants item from 550 droppings confirms the impression that the sharp-tailed grouse has very simple dietary requirements. Schmidt (1936) and Marshall and Jensen (1937) have made extensive field observations on the feeding of this species, and Snyder (1935) and Swenk and Selko (1938) have reported on the examination of 51 and 29 birds, respectively. The foods found by these authors in sufficient quantities to measure total only 48 species or genera when duplications are eliminated. Of these only 23 were found by two or more authors, or noted as an important food by even one

SHARP-TAILED GROUSE FOODS FROM ANALYSIS OF 550 DROPPINGS, COLLECTED IN HUBBARD COUNTY, MINN. OCT.–NOV. 1938

| *Food Species* | *Frequency of occurrence* | *Percentage by volume* |
|---|---|---|
| Polygonum convolvulus (Wild Buckwheat) | 94.5% | 10.2 |
| Symphoricarpos (Wolfberry, Snowberry) | 94.5% | 5.7 |
| Rosa (Wild roses) | 92.7% | 28.8 |
| Gravel[1] | 89.1% | 9.1 |
| Arctostaphylos uva-ursi (Bearberry) | 87.2% | 50.9 |
| Orthoptera (Grasshoppers) | 50.9% | 0.4 |
| Physalis sp. (Ground cherry) | 47.2% | 0.4 |
| Rhus toxicodendron (Poison ivy) | 14.5% | 1.7 |
| Pinus banksiana (Jack pine needles) | 10.9% | 2.1 |
| Chenopodium hybridum (Goosefoot) | 5.4% | trace |
| Agropyron sp. (Awned wheat grass) | 1.9% | 0.1 |
| Ambrosia artemesiifolia (Common ragweed) | 1.9% | trace |
| Crataegus sp. (Thorn apple) | 1.9% | 0.2 |
| Erigeron sp. (Fleabane) | 1.9% | 0.1 |
| Undetermined twig | 1.9% | trace |

[1] The volume of gravel has been calculated on the basis of total volume of all items in the droppings, while other volumes are based upon food exclusive of gravel.

writer. These more important forms are *Alnus* sp., *Artemisia* sp., *Arctostaphylos uva-ursi*, *Betula glandulosa*, *Betula papyrifera*, *Carex* spp., *Juniperus* spp., *Leontodon* sp., *Medicago sativa*, *Melilotus* spp., *Physalis* sp., *Polygonum aviculare*, *Polygonum convolvulus* *Polygonum dumetorum*, *Populus tremuloides*, *Prunus* spp., *Rhus toxicodendron*, *Rosa* sp., *Rumex acetosella*, *Salix* spp., *Sorbus americanus*, *Symphoricarpos* spp., *Trifolium* spp., *Vaccinium* spp. (blueberries), *Vaccinium oxycoccus*, *Zea mays*.

The present study and that by Swenk and Selko covered about the same period of the year and revealed in common a number of plants in significant quantities: *Rosa*, *Symphoricarpos*, *Physalis*, *Rhus*. The Nebraska crops and gizzards contained, however, so many succulent leaves, such as those of clover, alfalfa, and dandelion as to indicate that the absence of these leaves in droppings may suggest a serious limitation of the dropping-analysis method. In a small lot of sharp-tailed grouse droppings collected in March, 1940 in northern Minnesota, however, leaves of clover, *Chamaedaphne*, and *Ledum* were frequently recovered. This lot contained chiefly bud scales and other soft foods, suggesting that succulent leaves are recoverable from the droppings chiefly when the birds are not eating hard foods.

Schmidt (1936) discusses in detail the use of rose seeds by the sharp-tails. Certain authors believe that these hard seeds may be a substitute for grit, a supposition confirmed in a negative way by Schmidt's study, gravel being available and rose seeds not utilized to any great extent. Swenk and Selko found very little gravel in their birds, but many rose seeds—positive support for the theory. In the present study gravel was taken enough to constitute 9% of the volume of the droppings, but rose seeds were, nevertheless, found in quantity, an indication that the rose hips had been taken as food rather than grit.

## SUMMARY

The analysis of droppings as a

method of determining food habits of gallinaceous birds deserves wider application, although it has a tendency to exaggerate the importance of the harder items. Review of the chief literature on food habits of the carnivorous mammals determined by this method reveals a lack of uniformity in presentation of data. It is suggested that frequency of occurrence, volumetric data, and number of prey individuals should all be presented wherever possible to facilitate comparison with other studies. All published reports upon the autumn and winter foods of the sharp-tailed grouse reveal that the diet is relatively simple.

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Gustav Swanson
Division of Entomology and Economic Zoology
University of Minnesota
St. Paul, Minnesota

# THE STRAIGHT-LOG DAM

*David B. Cook*

Stream development is the art of improving environmental conditions for fish by revegetation on the banks and the use of simple engineering structures in the stream itself. Most of this work has been done on relatively small streams and for the benefit of brook and brown trout. In Britain, where the trout fisheries are valued highly, stream development has been going on for a century. It has come into prominence in the United States since 1930, chiefly through Government-sponsored conservation programs. The states of Michigan, California, and New York have pioneered in the field.

In New York, development of publicly-owned streams was begun in a small way in 1934. Large-scale operations started in the fall of 1935, when a program of fishing-rights purchase made available substantial mileages on first-class streams. Labor has been supplied almost wholly by the Civilian Conservation Corps. Many types of structure, built according to designs borrowed from the literature or from experience in other states, or conjured from thin air, were tried out. Most of them were found wanting. Choice finally settled on certain timber-and-stone structures as the best, most effective, and cheapest. Conspicuous among these are dockings, deflectors, and straight-log dams, the last of which is described herein.

In improving trout streams, it is important to prevent things that are harmful and to accomplish those that are beneficial. A deficiency of good pools is characteristic of many New York trout streams. The straight-log dam (Figure 1) is the best device we have found for aiding pool development. The essential of this dam is a single log laid across the stream and long enough to extend at least two feet into each bank. The top of the log is set level. A board facing, nailed to it on the upstream side, extends the full length of the log and into both banks. The boards should be 4 to 6 feet long and slope down $1\frac{1}{2}$ inches per foot. A space of $\frac{1}{4}$ inch is left between boards to allow for swelling. The upstream ends are nailed to a light tail-pole. The main log must be reasonably straight, not less than 7 inches on the small end, of durable wood, and with a minimum of taper. This last feature will save a lot of digging. All irregularities must be trimmed close so that the board facing sets true and level. For facing, sound, rough lumber in widths from 6 to 12 inches is suitable.

We have learned by experience that it is not necessary to make these dams high. On streams up to 20 feet wide, a height of 6 to 8 inches *from the stream bed in mid-channel to the top of the board facing* is adequate and 12 inches is the maximum even on the biggest streams. But such a dam spreads the water in a thin, even sheet over the full width of the stream and the ends of the dam are very vulnerable to erosion.

The next step is to reduce the width of the spillway. The exact percentage of reduction in each instance is a matter for the builder to decide but we have

found that a 40 per cent opening on small, to 60 per cent opening on large, streams works out well. This reduction is accomplished by the use of two deflector logs extending upstream into the bank at an angle of 45°. These are spiked to the main log and slope *up* into the bank with a pitch of 1 inch per foot. It is not essential that the spillway be centered; it can be off-set either way, as desired. The logs should be about the same diameter on each

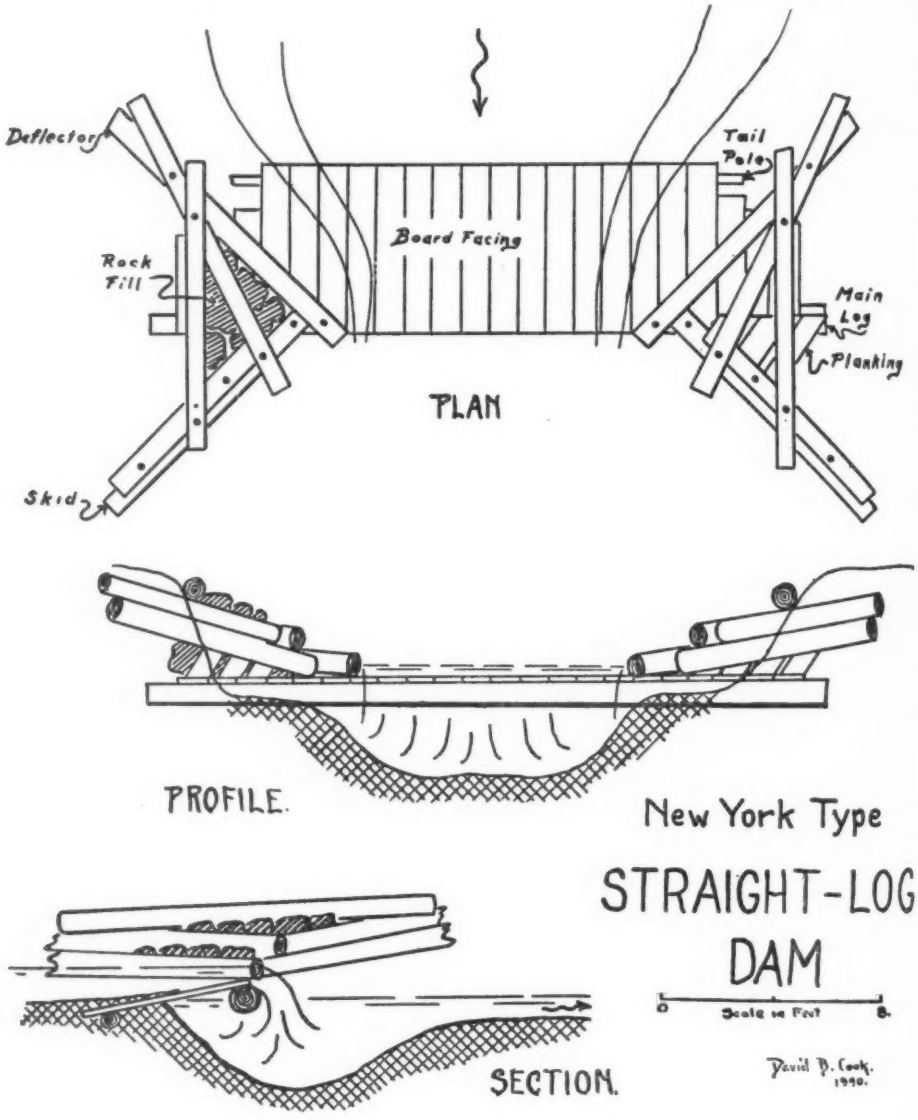



Figure 1

side of the spillway and not less than 6, preferably 9, inches in diameter.

To protect the ends of the main log, two skid logs, similar in placement to the deflectors, are set on the downstream side. These slope *up* to the bank with a pitch of 1 to 3 inches per foot and are joined to the main log with 2-inch planks, which prevent the stone fill from dropping through. For best results, particularly in handling running ice, the downstream ends of the skid logs must be considerably higher, and the upstream ends of the deflectors slightly higher, than the spillway. If the bank be low a single log, parallel with the bank and spiked to the skid and deflector, will be sufficient finish. For higher banks, one or even two steps will be needed. When the timber work is completed, gravel is swept over the board face and the deflectors are filled with stones. Rocks weighing 20 to 50 pounds are best.

Straight-log dams are cheap to build. On dams of 20-feet span, digging the trench for the main log and facing will take 2 or 3 man-days, depending on the hardness of the bottom, with perhaps another man-day for the pits where the ends of the skids and deflectors are buried. The time required for construction will vary with the site and the skill and experience of the crew but should not exceed 4 man-days, provided materials are at hand. The bill of material for the dam shown in the sketch is as follows:

150 linear feet of peeled hemlock logs
150 board feet of rough hemlock boards
4 ½″×16″ dock spikes
12 ½″×12″ dock spikes
2 pounds of 10-penny nails

The only unusual tool needed is a ½″ car-bit for boring the holes for the dock spikes. Because of the great diversity of material prices and wages, no cost figures would have general application.

Unquestionably, the best wood for this work is eastern hemlock. The trees should be cut and barked during the peeling season, May to September. Material is delivered on the job in tree lengths for economical cutting.

In general appearance these dams resemble the non-silting type but the basic principle is not the same. The non-silting dam is essentially an impounding dam and depends upon a narrow throat to hold back water by friction.

The functioning of the straight-log dam is shown in Plate 14. Flow is concentrated and plunged over a low fall. This scours out a basin-shaped pool extending back under the floor and the skids. The eroded material is carried off downstream. The size and shape of the pool will depend on the character of the bottom. Sand and gravel erode easily, while coarse rubble is moved with difficulty. Stones of less than 5 pounds weight are readily washed out. If the larger stones are removed as they loosen, the pool will continue to deepen. Stability is reached when the shape and hardness of the bottom together with the cushioning effect of the water in the pool balance the erosive action of the fall. This type of dam has several conspicuous advantages. It will operate on a minimum head and can be used on streams of low gradient. Because of the step arrangement of the deflectors, the effective spillway increases as the water rises.

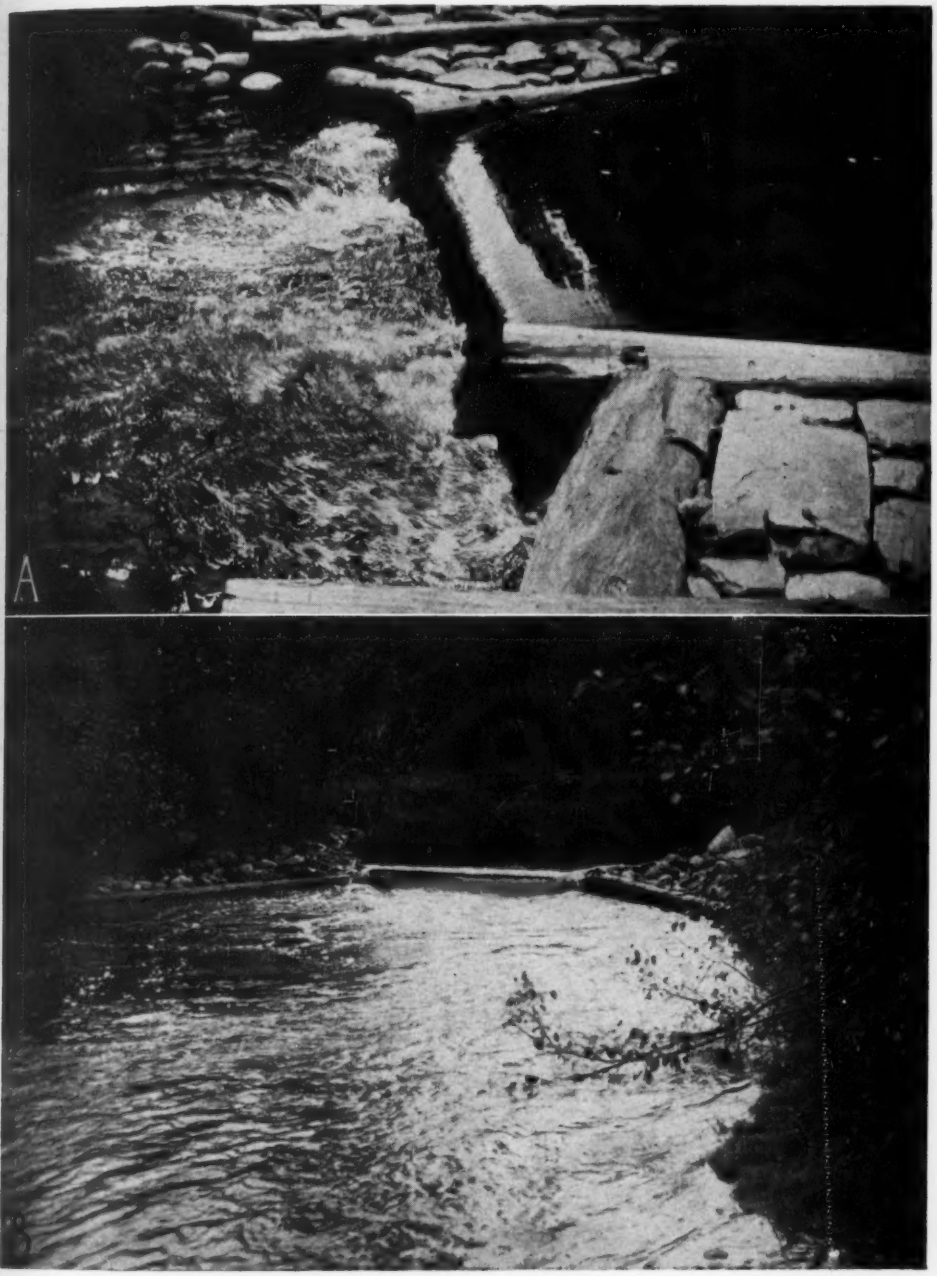
With minor exceptions, the streams of the Northeast move a considerable bed load of gravel and sand, *which promptly fills up any impounded pool.* The great effectiveness of the straight-log dam lies in constricting the flow and thus continually scouring out the plunge pool. As the pool is dug by the stream, so the stream will keep it clean and no maintenance is required. This is opposite in action to an impounding dam, the tendency of which is to fill up. The plunge pool of the straight-log dam is dug *below* the normal bottom level and will be the last place to hold water if the stream dries up. Adequate shelter is afforded under the floor and the skid logs. Once the pool is scoured out, the energy of the falling water is expended in the pool itself, making a great column of bubbles, which thoroughly aerate the water and may assist in oxidizing dissolved organic acids. The pool impounded by a straight-log dam is small, seldom longer than 50 feet. It is big enough, however, to catch a drift of leaves that makes an excellent hatchery for trout food organisms.

The skid logs tend to drive the water to the middle when the stream is up, often making a wave several inches high. As this surge spreads out and loses its velocity, its burden is deposited against the bank, tending to make the stream narrower and deeper and to lessen lateral cutting into the banks. At flood these low dams are completely submerged but the bottom action is still powerful.

In locating the dams, care should be taken to place them where they will cause the least change. They should be built at the *upper end* of existing pools, that is, at the foot of the riffles, so that there will be a minimum of impoundment.

The straight-log dam is a cheap, stable, and effective stream management device, with many virtues and few weaknesses. It is one of the best pool developers known.

David B. Cook
State Conservation Department
Albany, New York




A (*Upper*)—Straight-log dam on the Salmon River, Lewis County, New York. Opening is 50 per cent, fall 10 inches. Built in 1938.

B (*Lower*)—Straight-log dam on Easy Koy Creek, Wyoming County, New York. Opening 40 per cent, fall 6 inches. Built in 1939.

UNIV. OF MICH.

# THE WOODCHUCK AS A SOIL EXPERT

*A. E. Moss*

The University of Connecticut is located within the eastern upland region of Connecticut. This region was almost entirely forested at the time of settlement about 1700. The original soils were of glacial origin and probably rather shallow and of moderate to poor fertility. The economic cycles of the past 200 years have resulted in extensive shifts of land use as evidenced by signs of agricultural activity to be found in much of the present forested area. All forests have been cut from time to time as markets warranted. The land use practices have resulted in a deterioration of the original soils in depth and fertility through erosion and improper crop practices. The present ratio of woodland to crop land is about 50:50. This forest cover represents interrupted ecological successions on soils that are too poor to support modern agriculture.

The forests of this area are lacking in conifers and a study was begun on University property to learn what the effect of coniferous plantations might be on wildlife distribution. At the same time a detailed soil survey was made by a member of the Agronomy Department of the State University. Not being a soils expert, the writer was much interested in the procedure. The area was traversed at two chain intervals with frequent side excursions. The soil was sampled by means of a soil auger and it is safe to say that at least one sample was taken on each square chain.

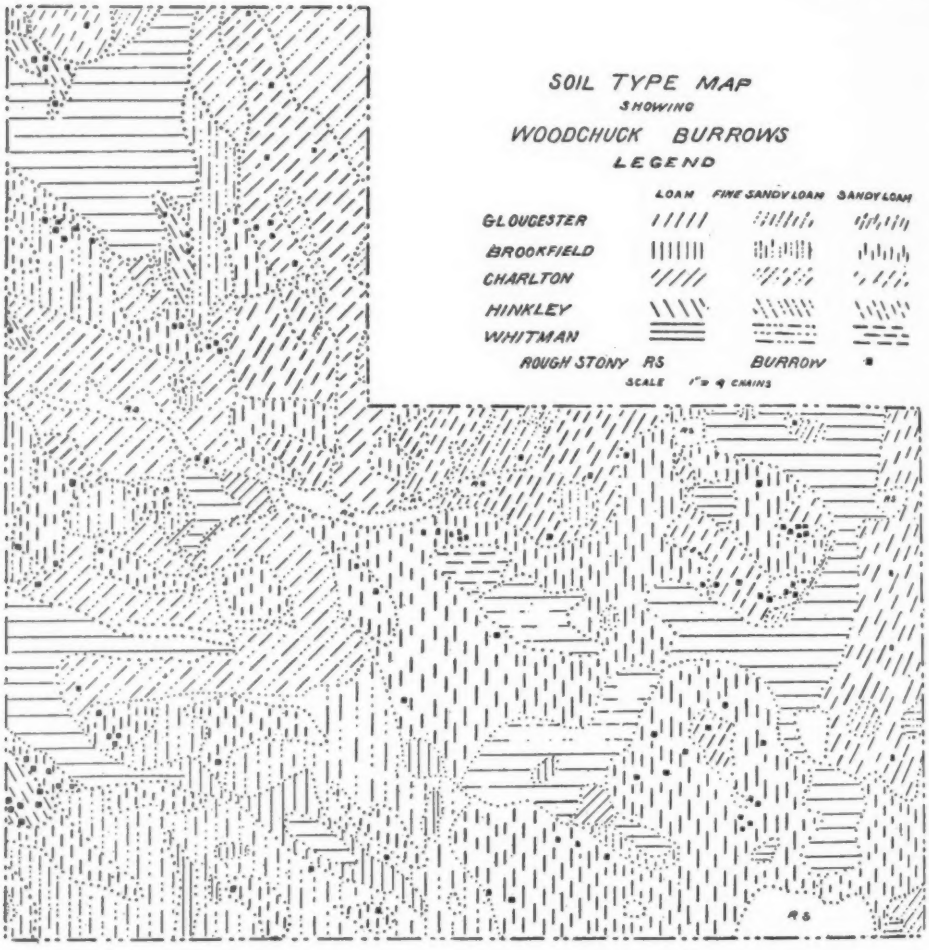
Five soil series were represented within the area, together with certain additional patches too rough for classification that were designated as rough stony. The soil types, which were determined by sequence of color and the physical structure, were much interspersed. Their distinctions were sufficiently apparent so that the author could ordinarily distinguish them with very little difficulty.

Within the series the soils were further subdivided, according to their various-sized particles, into loam, fine sandy loam, and sandy loam. The field classification was entirely by "feel." The soil expert would bore about 6 inches and then rub random samples from the auger between his fingers. Then he would bore 6 inches more and test the sample. His fingers were sufficiently sensitive to permit the placing of all soils in their proper classification. It is not too hard to distinguish the extremes but the boundary between sandy loam and fine sandy loam is not to be determined by the layman and he often wonders just how consistent the expert is in his separation of classes by this apparently rough technique. The writer, however, found the expert consistent even when certain areas were resampled without the expert being aware of the fact. The soil series and class boundaries were plotted with traverse board in the field. In all cases, the boundaries were interpolated by the expert from the nearest boring and not actually "run out."

As the bearing of soils on the distribution of vegetation and wildlife was the objective of the study, the occur-

rence of woodchuck burrows, either active or abandoned, was noted on the field work map. As these records were studied it became more and more evident that there were two experts at identifying physical characteristics of the soil.

Woodchuck burrows were apparently located at random throughout the area. They did not check with present or past evidence of cultural features and had no definite relation to topography or aspect. However, when plotted on the completed soil maps they proved to be restricted very closely to what the soil expert classified as sandy loam. The woodchuck apparently did not care whether the soil was waterlaid Hinckley, yellow Gloucester, or red-brown Brookfield but he was quite exacting in requiring that it be sandy loam and not fine sandy loam even if both were equally well drained.




Of the 115 burrows plotted for 132

acres (Figure 1) 100 were in sandy loam as designated by the human soil expert. The remaining 15 were in fine sandy loam and missed the sandy loam as plotted on the map by an average distance of 28 feet. The greatest distance was 150 feet; only 4 were over 50 feet, whereas 8 were less than 20 feet from the boundary of a sandy loam area on the map.

In only two cases did terrain appear to have an influence. The rough stony type with cracks between ledges was one instance and a small outcrop of fine sandy loam within an area subject to excessive moisture was the other. No attention was paid by the human soil expert to the occurrence of burrows. As can readily be seen from the map, the soil boundaries are very irregular, and as already stated they were interpolated and not "run out." Therefore it may well be that burrows apparently in fine sandy loam within a chain's distance of a sandy loam area may actually be within the sandy loam classification. If so, the woodchuck may still be nearer 100% in his selection of what the human has classified as "sandy loam."

A. E. Moss
University of Connecticut
Storrs, Connecticut

# TRAPPING, HANDLING, AND MARKING FOX SQUIRRELS

*Luther L. Baumgartner*[1]

In conducting population studies of fox squirrels, one is continually confronted with the problem of locating and observing a satisfactory number of individuals. They are very wary and it is seldom possible to watch them for an extended period. It is, moreover, desirable to study these animals at closer range than that afforded by stalking. Live-trapping proved to be the only way by which the individuals could be closely examined without killing them. A considerable amount of information can be secured by such trapping, but the value of the procedure depends upon the efficiency of the traps, the trapping methods used, and the facilities available for handling the live animals.

The squirrel trap here described was designed by the writer and used for about four years. Of the nine different types of traps tested in catching 1,100 squirrels alive, this trap was considered to be the most efficient. It is a humane trap as the squirrels seldom sustain injuries in it, and fatalities have been less than one per cent. The first reaction of squirrels after being trapped is to attempt to get out, and, in so doing, they fight the trap. Broken incisor teeth, cut and torn lips, and scarred heads were common while metal and part metal traps were used. The wooden traps, now exclusively used, require more frequent repair but compensate for the extra time and money used by the better data obtained from uninjured animals.

The handling cage (Plate 15 and Figures 5–13) was designed specifically for fox squirrels, but was also used for five other species of mammals. This cage allows one to examine the entire external anatomy and teeth of a squirrel without risk of being scratched or bitten.

## The Trap

The trap (Figs. 1–4) is simple in design, having been modeled after the common box trap, but modified for fox squirrels. A trap suitable for catching squirrels must have light coming in from the rear, must be tight-fitting, must have a self-locking door, should have a minimum of working parts, and should have all of the mechanism inside.

The trap is constructed from No. 2 yellow pine which is a hard and an inexpensive wood. Light is admitted through double-strength glass placed in grooves at the rear of the trap. This glass should be snugly fitted to keep the squirrels from chewing around it. There is little possibility of the glass being broken if it is properly inserted.

The trap door is hung on a No. 9 wire (Fig. 4-J) extended through the sides of the trap. This door has a clearance of $\frac{1}{8}$ inch on either side which allows for some warping of the sides of the trap, but does not give the squirrels enough room to start chewing. Door slams (Fig. 2-H) $\frac{1}{2} \times \frac{1}{2}$ inch are provided to keep

[1] Former research fellow of the Ohio Wildlife Research Unit in cooperation with the Ohio Division of Conservation, U. S. Biological Survey, American Wildlife Institute, and the Ohio State University, Dr. L. E. Hicks, Leader.

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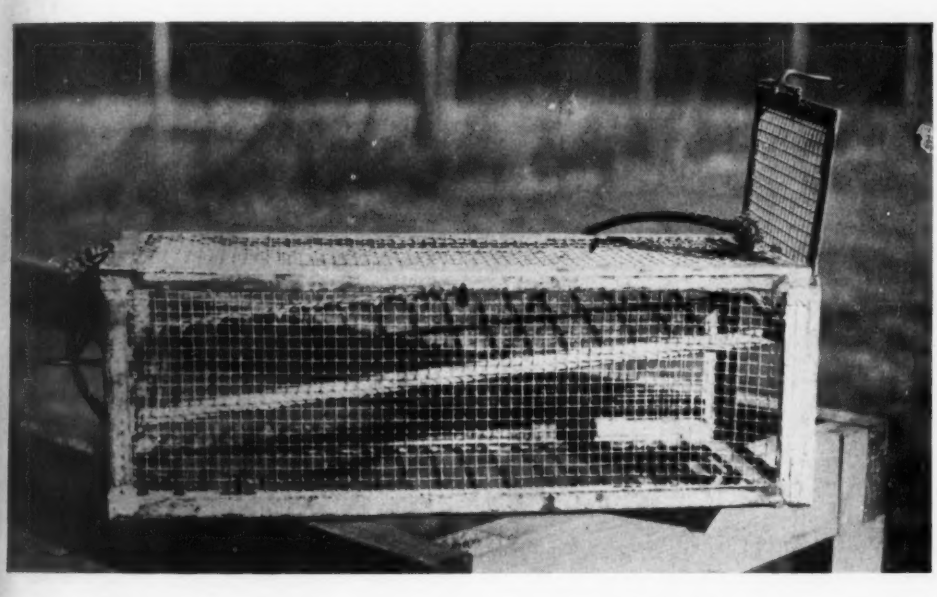

A. (*Upper left*)—Handling cage in position to receive squirrel from trap.
B. (*Upper center*)—Trap turned on side with door held open by fingertips.
C. (*Upper right*)—Lead-bait of corn scattered on top and in front of trap.
D. (*Lower*)—Handling cage.

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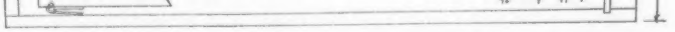
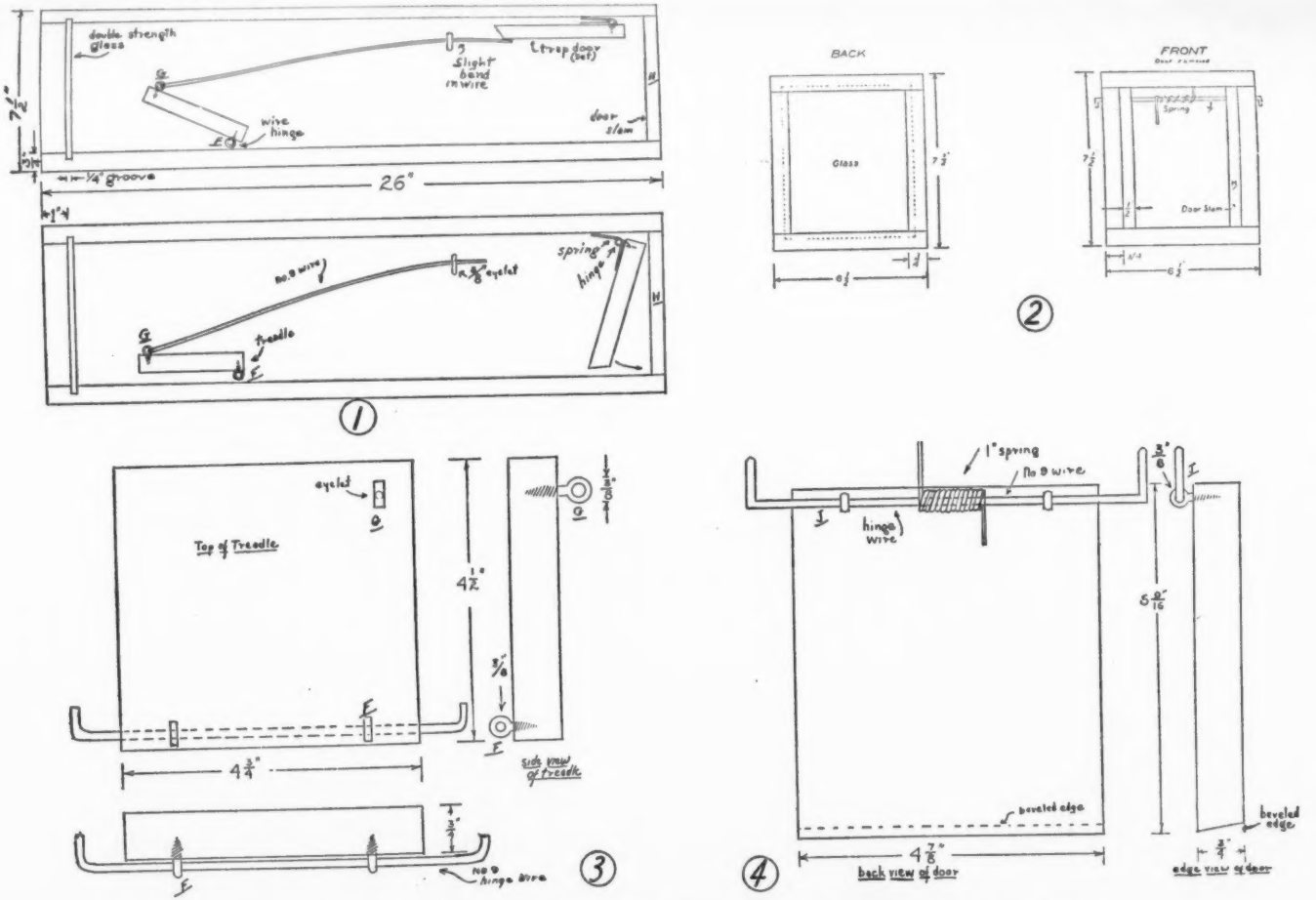
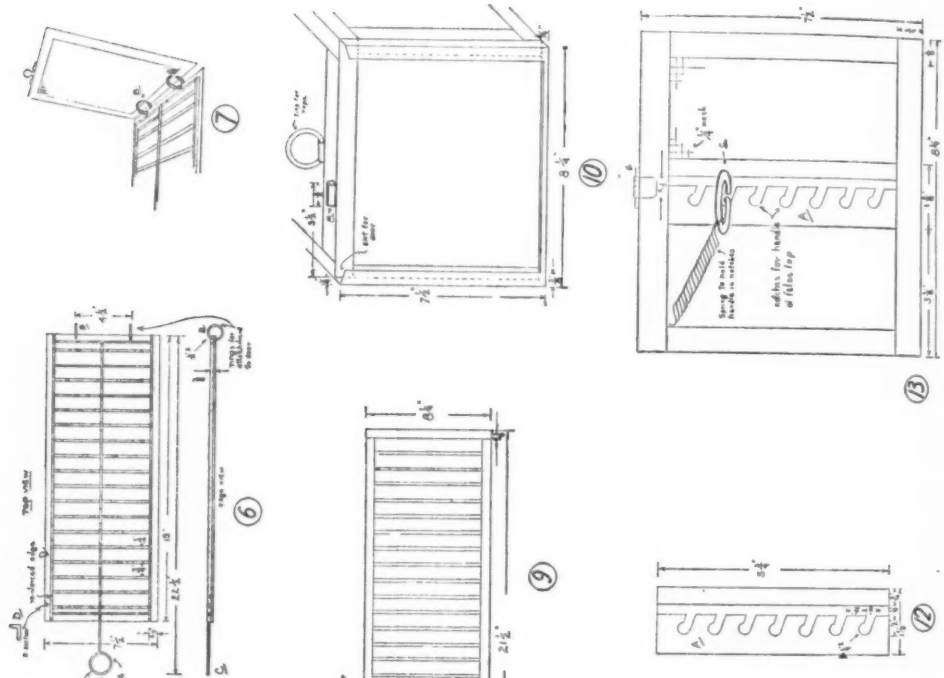
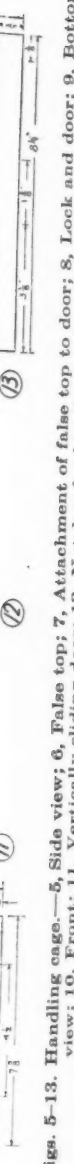





Figs. 1–4. Squirrel traps—1, Side views; 2, End views; 3, Treadle; 4, Swinging door.



Figs. 5–13. Handling cage.—5, Side view; 6, False top; 7, Attachment of false top to door; 8, Lock and door; 9, Bottom view; 10, Front; 11, Vertically sliding door; 12, Notches for handle of false top; 13, Rear view.



Figs. 5–13. Handling cage.—5, Side view; 6, False top; 7, Attachment of false top to door; 8, Lock and door; 9, Bottom view; 10, Front; 11, Vertically sliding door; 12, Notches for handle of false top; 13, Rear view.

light from entering around the edges of the door. Squirrels are less likely to chew on the door if the light is kept out. A spring with 1½ pounds tension is added to make the door drop quickly and supply enough pressure to lock it. The lock consists of two screw-eyes attached to the top of the door and hung on the No. 9 hinge-wire. The holes of the screw-eyes are slightly larger than the hinge-wire. The lock operates as follows: the spring and the weight of the door causes the door to drop with force; because the screw-eyes are slightly larger than the hinge-wire, the door, after hitting the bottom of the trap, moves forward a fraction of an inch and lifts itself off the hinge-wire. Then the door, instead of hanging on the No. 9 wire, is wedged between it and the floor of the trap. It is almost impossible to open the door from within, if it has been properly fitted. The spring should have not more than 1½ pounds tension or the trap will be difficult to spring.

The treadle (Fig. 3) also is hinged by two screw-eyes to a piece of No. 9 wire running through the bottom of the trap. The treadle is connected to the door (when the trap is set) by a long piece of No. 9 wire. This trigger wire is held in place by a screw-eye on the side of the trap and is slightly bent, so that it will slide from under the door more easily.

There is no device on the trap for holding the door open while the squirrel is being taken out, but it can easily be held open by a finger (Plate 15—A, B). Occasionally squirrels refuse to leave the trap readily. These individuals can be removed by prying up the top board near the back of the trap. Through this crack a stick can be inserted to poke the animal out.

## THE HANDLING CAGE

The handling cage (Plate 15 and Figures 5–13) was devised and constructed primarily for fox squirrels with dimensions to correspond. It consists of a metal frame covered with ¼ inch hardware cloth on three sides and on the back. The bottom (Fig. 9) has 3/16 inch strap-iron slats spaced ¾ inch apart. These iron strips are soldered to the metal edges of the cage. Inside the cage is a false top (Fig. 6) made like the bottom but having its edges reinforced with L-shaped strips of sheet metal. It is held in place by two rings (Fig. 7-B), 1 inch in diameter, fastened to the bottom of the door. The handle of the false top extends through a slot (Fig. 13-A) in the back of the cage and is held in place by notches cut in a strip of sheet metal 1 inch wide. A short door spring holds the handle in the notches. The sliding door (Figs. 10 and 11) made of ¼ inch hardware cloth operates in a ¼ inch slot. The lock (Fig. 8-K) made of No. 9 wire is attached to the door by two metal loops (N) and is pushed through a third loop (M) attached to the cage. A carrying rope is tied to the two metal rings (E).

The cage is operated as follows: the handle of the false top is raised to the top notch, then the door is pulled up. The cage is now placed in front of the trap (Plate 15-A) and as the squirrel enters the cage, the door is closed and locked. The animal is held quiet for examination by pushing the false top down against it and locking the handle in one of the lower notches. The ventral side of the squirrel is now in position for examination. As squirrels always try to stay upright, the dorsal side of the ani-

mal can be brought into position by releasing the handle, turning the cage upside down, and again fastening the handle in a lower notch.

### TRAPPING SITES

In choosing trapping sites it is important to take the trap to the squirrel, for there is a limit to the distance over which squirrels can be lured to a trap. Much can be learned about animal behavior, however, by setting the traps in different locations. Trap sites aid in the study of feeding, behavior, range, and paths and trails.

Trap sites at the base of trees containing used dens or nests result in the most catches. This type of site is advisable in unfamiliar woodlots. Squirrels do not always climb the tree in which the den or nest is located, but sometimes ascend a near-by tree and cross over to the nest or den tree. In these instances the trap should be placed at the base of the primary tree.

Traps are often set on or near stumps and fallen logs that are used by squirrels as runways, eating places, or lookouts. These sites can be located according to signs such as fresh food fragments or numerous recent claw marks.

Trapping on trails has been quite successful but the trails are not as definite as are those of rabbits, woodchucks, or muskrats and usually can be traced only after observing individuals over a period of days. The location of certain trees, stumps, logs, and earth mounds often determine the course of these paths. Trails from woodlots to adjacent corn or wheat fields are distinctive and can be identified by the corn husks or wheat straw scattered along them.

Random distribution of traps is very effective in pastured woodlots but yields only moderate returns in unpastured woods.

Selection of trapping sites for different seasons of the year should be guided by the behavior of the squirrels. In autumn when squirrels are cutting off acorns and nuts, the traps should be placed near hickory, oak, or beech trees. During the winter months, traps are best placed where the food had been cached. Trapping near used dens or nests is profitable in winter and early spring, but is generally unproductive in late spring and summer. No orthodox trapping technique has been devised for the summer season, but trails, rail fences, fence rows, stumps, logs, and fruit trees have been some of the better sites. Trapping at this time of the year will tax the ingenuity of the trapper.

A number of different baits have been tried, but shelled corn, which is easy to handle, has proved best. Most of the corn is placed in the trap, but a small amount of it also is laid in front of and on top of the trap as lead bait (Plate 15-C).

### MARKING SQUIRRELS

Considerable effort has been expended in the development of methods for distinguishing individual squirrels. Two procedures for marking the sexes for field identification and two of the more satisfactory methods for individually marking squirrels will be described.

*Distinguishing Sexes.* The value of a method for field recognition of the sexes in mammals that show few or no external secondary sexual characters is obvious in connection with attempts to observe breeding habits. One method used was to clip quantities of hair from

various parts of the animals. Such markings were visible, however, only when made on the tails. The hair was shaved off the left side of about the terminal six inches of the tail in males and off the right side in females. These markings were readily observable in the field but seldom lasted for more than six months. Renewing them at regular intervals, however, is feasible.

The second method involves the use of dyes. Two colors: Gentian violet and Biebrich scarlet, in chloroform, were used. The chloroform served to dissolve the oil on the hairs and thus facilitated staining. The dyes proved to be of little value as the colors faded rapidly, seldom persisting for more than four weeks.

*Distinguishing Individuals.* Ear-tagging, with serially numbered tags, and toe-clipping were the best methods found for marking individuals. The ear-tags were used specifically to attract the attention of hunters. Tags taken from squirrels killed by hunters afford the present best-known vouchers for determining dispersal. Population data gathered by the investigator, however, are based upon identification of toe-clipped individuals.

To date no satisfactory ear-tags are on the market but wing-bands and fingerling fish-tags can be used if the latter are re-bent as indicated by the accompanying figures (14–15).

The average life of a fingerling fish tag on fox squirrels is from one to two years. The other tag which proved to be more satisfactory is known as Style-1005, No. 3, wing-band, manufactured by The National Band and Tag Company, Newport, Kentucky. Although originally designed for use on bird wings, it is readily attached to the ears of squirrels. These tags appeared to remain on the animals indefinitely.

Fig. 14. Original size and shape of fish-tags.

The toe-clipping method consists of removing certain toes from different feet, according to a standard system. Toe-clipping, properly done, is far superior to any other marking method thus far tried. Removing a toe leaves a

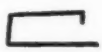


Fig. 15. Size and shape of fish-tags after being re-bent for squirrels.

mark that remains with the animal throughout life. The following pattern was used for squirrels (Figure 16).

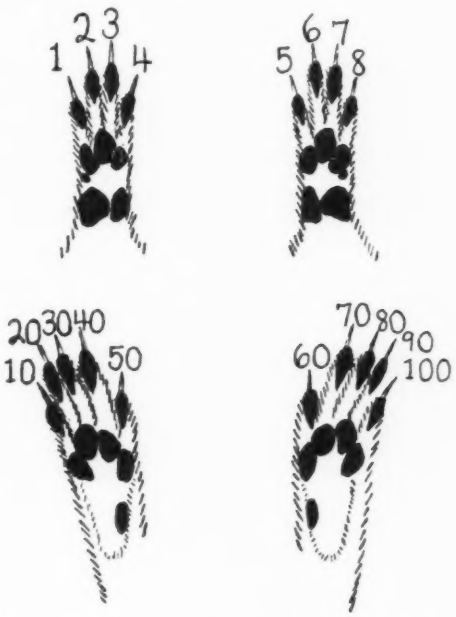



Fig. 16. Manner of numbering toes for the toe-clipping method of marking.

The toes are clipped while the squirrel is on its back, and the number diagram is based on a ventral view of the feet.

The cut should be made near the base of the toe. Squirrels often lose toe-nails from accidents; hence, if only the toe-nail or the tip of the toe is amputated, the markings due to toe-clipping may be confused with injuries from other causes.

Before making extensive use of this system, the toes of five squirrels were clipped in various combinations. The wounds were completely healed in from three to five days. The removal of toes (usually not more than one per foot) does not appear to hinder or in any way impede the arboreal activities of the animals. An extreme example of the adaptability of squirrels is an adult female which is still quite active, even though her left front leg was cut off by a vermin trap three years ago.

Luther L. Baumgartner
Dept. of Conservation
Lansing, Michigan

# EDITORIAL

## On the Social Potentialities of Wildlife Management

It may be easy, in view of the uncertainties if not menace of the future, to feel that wildlife management is a piddling occupation for grown men. The field, as we know it, is only of recent development in this country and is an offshoot of ecology and conservation—which are themselves comparative newcomers not wholly accepted by the public as integral to existence. True, our association with the "half-billion dollar industry" supported by hunting and fishing, etc., may give us status with business men who are not already convinced that what we are doing is nonsense, but, even in better days, there are plenty of people whose reaction, for example, to a monograph on a wild plant or animal is that the author could have devoted himself to more practical ends.

How much wildlife management may be judged essential to human welfare or only another luxury is, of course, something that we may be due to find out. The majority of those in our field, if called upon for statements, would probably lay stress upon either the economic or the recreational aspects of their endeavors, and they may well do this. A great deal of the management that falls into the category of economic biology should stand a good chance of being justifiable under any circumstances; and emphasizing the need for administrating our wildlife resources for their fullest recreational advantages should be in order—at any rate to the extent that a standard of living may be hoped to safeguard health and morale.

Let us examine, in particular, the question of the morale of the members of our Society—apart from, but without belittling, problems of livelihood that confront them. Among our membership, the same persons that are engaged in work the practicality of which is evident will doubtless be the ones to keep up their spirits as well as anyone. The wise control or utilization, alike, of economically important wildlife requires that there must be informed and capable men in key positions, lest costly or irreparable mistakes be made in the name of a supposed public need. The esthetes, too, may derive comfort and dignity from their efforts, for the troubles and miseries of mankind make it all the more imperative that we retain all we can of what we have that is conducive to sanity.

It is the participants in difficult, longtime, nonspectacular programs of wildlife administration, teaching, or research that—regardless of whether they meet with outside appreciation and support—may find especially formidable the psychological odds against them. A sense of futility is not unknown to conservation biologists during "normal" times, although usually for reasons of the magnitude of obstacles to accomplishment rather than lack of confidence in the worthwhileness of their objectives. Some, indeed, keep on in the face of continued discouragement simply because they still find their work as enjoyable as anything they would be likely to do; others because they believe that, irrespective of deadlocks and setbacks,

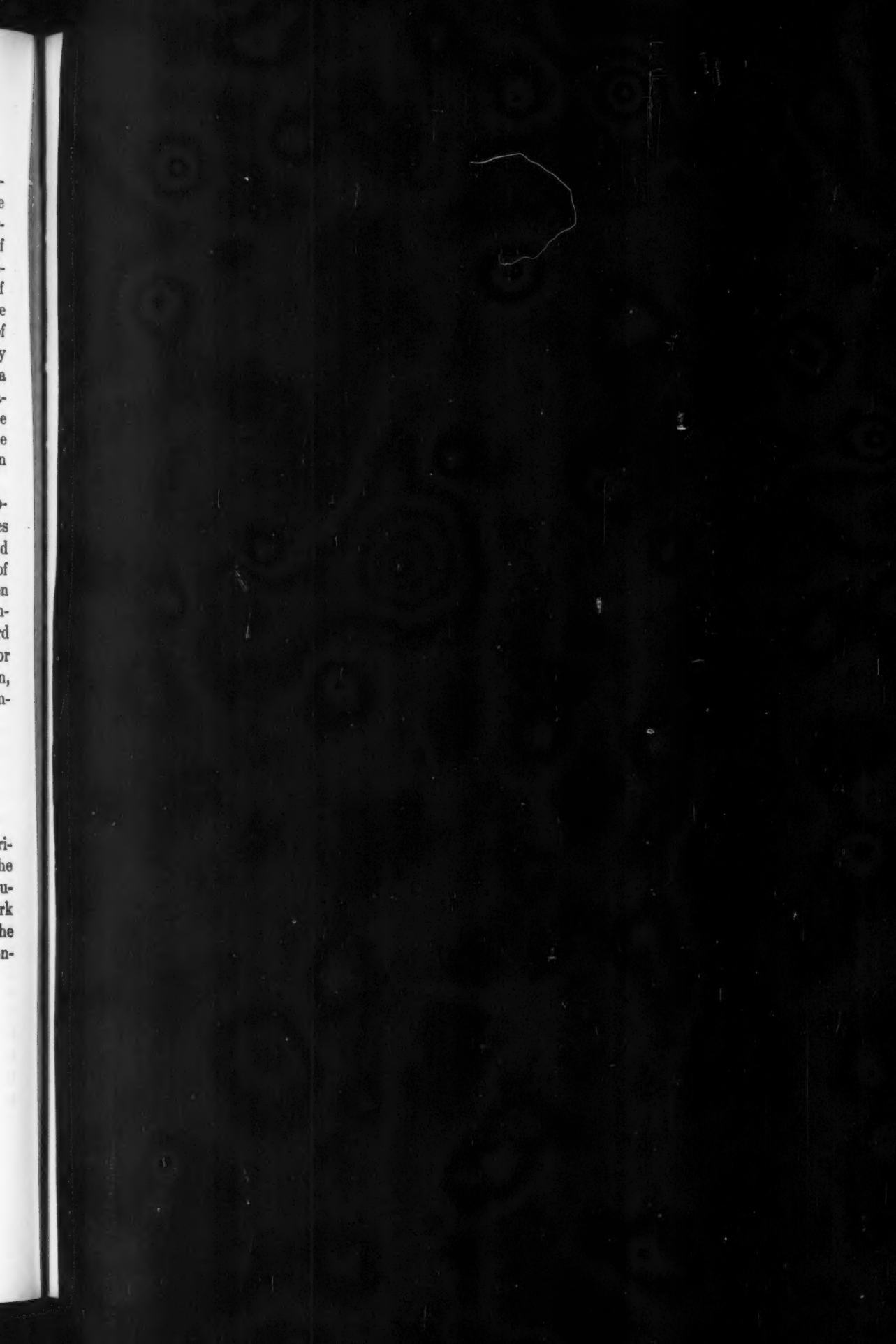
they are conceivably making progress that can be calculated at least in terms of years.

Nevertheless, despite the slowness with which it may be able to demonstrate "results," this group may ultimately contribute to the welfare of poor old fumbling man in a way that it may rarely think of. The idea that wisdom may be gained through study of the so-called lower animals is by no means new, nor restricted to a single philosophy; but it is quite appalling how few people of real influence in human affairs show awareness of the biological backgrounds of sociology and economics and how often, consequently, their concepts betray basic errors. Over and over again, one may see parallels in population phenomena and behavior of man and of other mammals. The parallelism does not stop with mammals, and the deeper one explores the ecology of living things the more pronounced it seems to become and the greater the lessons that might be extracted from it.

In wild populations may be found the equivalent of slums and of ease, intraspecific displays ranging from the natural viciousness of individuals and the strife of desperation to the mellow tolerance of contentment. The effects of gradual changes may be studied, likewise the impacts of crises. The roles of hereditary make-up and of immediate necessity in conditioning responses of animals to environmental stimuli may be somewhat appraised. And criteria take form by which optimum population densities for given habitats may be differentiated from those that may be unfavorably low or undesirably, or even dangerously, high.

The outlook for modern man may appear dismal, but, if our unhappy species ever does learn to manage itself and thus earn a measure of peace, some of the foundation may perhaps have been laid by workers in ecological fields, including our own. We need not regard ourselves as instruments of destiny nor indulge in any romantic exaggeration, whatever, to recognize the social implications of our work.

PAUL L. ERRINGTON

## NOTE

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